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THE GALVANIC CURRENT
AND
LOW VOLTAGE WAVE CURRENTS
IN
PHYSICAL THERAPY

PRINTED IN THE UNITED STATES OF AMERICA

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by
Frederick H. Morse, M. D.

GALVANIC CURRENTS
AND
LOW VOLTAGE WAVE CURRENTS
IN
PHYSICAL THERAPY

BY

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FOREWORD

This Book is written so that the busy practitioner of medicine who has little time to peruse exhaustive medical literature, or experiment in new fields, may be enlightened quickly.

A little concentrated study into the basic principles of the direct current in order that the "**why**" may be understood and the "**how**" simplified.

It has been considered unnecessary and superfluous to have a display and description of apparatus in this book. Such information is easily obtainable from manufacturers, or their representatives when desired. Knowledge of the necessary apparatus for the production of electric currents is indispensable for the operator, but in the nature of the instruction contained herein it would have a strong tendency to detract from and confuse the reader whose object is to readily absorb the writers' ideas on the fundamentals, and apply his therapeutics to his apparatus at hand, or what he might obtain.

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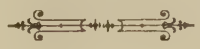

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PART I

GALVANISM

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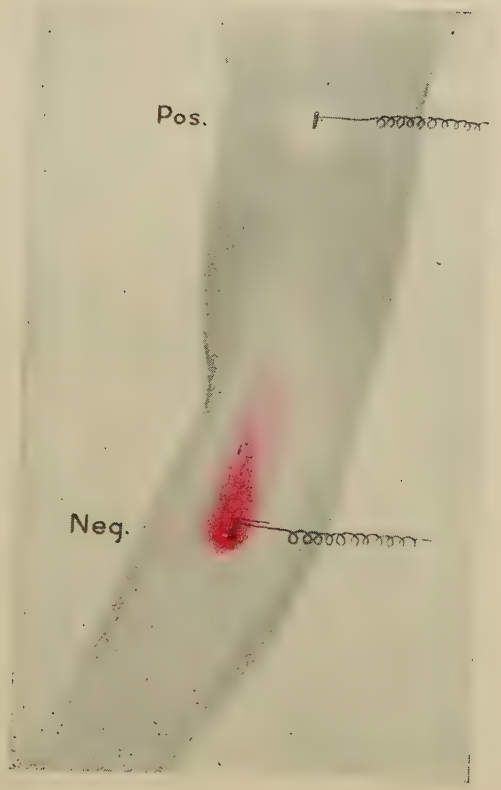

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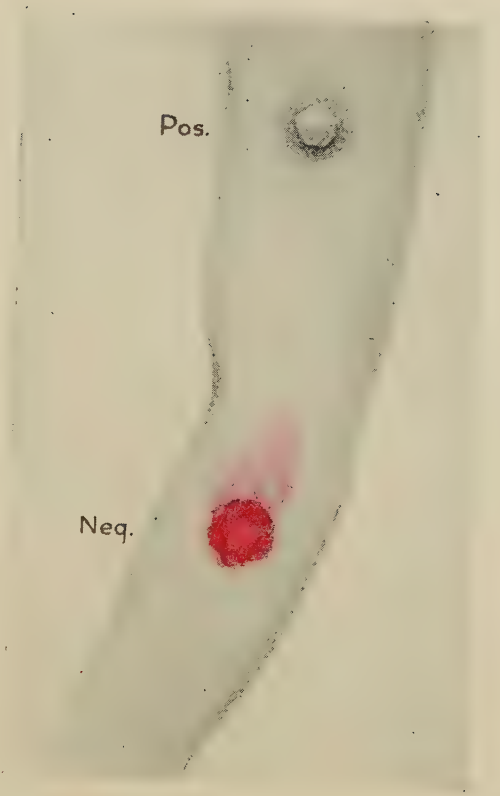


Two diagrams (shown on opposite page) representing as described in the text in chapter 5, page 25 the local polar affects on the skin of the galvanic current. The area about the needle at the positive pole shows a condition of anemia, and at the negative pole hyperemia. The diagram No. 2 represents the two forms of burns that may be produced by metal contact on the skin by the galvanic current. It is observed that at the positive pole the eschar is contractile in its outline, and of a grayish color illustrating its haemostatic effect. At the negative pole there is produced under the same condition as in the description of the positive pole action a hyperemia in and about what appears to be a soft ulcer.

THE GALVANIC CURRENT

AND

LOW VOLTAGE WAVE CURRENTS IN PHYSICAL THERAPY

The increasing use of high frequency electric currents in medicine and surgery has caused many medical men to begin the use of these powers in their practice without familiarizing themselves with the low voltage currents. This is to be regretted, not only because of the loss of valuable agencies for relief, but because a comprehension of the low volt direct or galvanic current is essential to an understanding of all forms of electric energy. It is electric force in its simplest, rudimental form; a stream of electrons from the negative pole passing through a conductor like a stream of water through a pipe, carrying energy for transformation into useful work at any point desired. It is this energy, transformed in differing ways outside or inside the body, that produces all the methods of electrotherapeutics.

Besides this fundamental relationship to all electric methods, or modes of employing electric energy in medicine and surgery, the direct current, called galvanic by medical men, has been used by physicians for a hundred years as a remedial agent, its scientific study covering more than half this time, beginning with the German clinicians and teachers Remak and Erb, who established clinical facts of present importance when chemical primary batteries were the only source of the energy, and units of measurements, as well as means of accurate measurements, had not been devised. The works of Remak, Erb and Von Ziemssen, and of the English authors, Althaus, Poore, Steavenson and Sir Lewis Jones are today valuable mines of clinical information on galvanic surgery in particular, despite the fact that the

currents employed by the earlier of these writers were measured by the number of cells used, milliamperes and meters not having yet been devised. The clinical material of a medical character is less valuable, chiefly because of the indifferent diagnoses of the day.

The other forms of low voltage electric energy, the low voltage wave currents, deserve the special attention of medical men because apparatus for the stimulation of the contractile organs of the body in wave periods suitable to each is now available; these generators, moreover, being power driven, may be set for treatments of durations more likely to produce results than laborious hand applications.

To these uses of low volt currents—galvanosurgery and power wave stimulation — should be added the indicated uses of the chemical effects of the galvanic current, including displacement of body ions and diffusion of certain drugs to moderate distances beneath electrodes.

The following statement of the rudimental physics of low voltage electric currents in such a conductor as the human body is intended for physicians who are rusty in their medical physics, or who graduated before such studies were required. Those who are familiar with these interesting premedical studies may turn at once to their clinical applications; but no physician can prescribe or apply intelligently this physical force in medicine without a knowledge of the basic laws governing it.

CHAPTER I

THE GALVANIC OR DIRECT CURRENT

Why Electricity Flows in a Current—Conduction of Electric Current—How Electricity Flows in a Conductor—Electric Pressure or Voltage—Mode of Producing Sufficient Pressure in a Galvanic Current—The Unit of Pressure: The Volt—Resistance—The Unit of Resistance—The Ohm—Table of Specific Resistance—Volume of Amperage of an Electric Current—The Unit of Volume, the Ampere—Importance of Shape and Duration of a Wave—Wave Frequency in Low Voltage Currents.

The galvanic current is a unindirectional current of electrons, that is, a current of electrons passing in one direction through a conductor, hence the name of *direct current* by which it is known to physicists. It was first discovered by Luigi Galvani, an Italian physician in the famous frog's leg phenomena hence the name still used by physicians, but early physicists more properly called it after the Italian physicist Volta, who corrected Galvani's misconception of the need of living muscle and nerve for its production, and first produced it from a battery made of alternate discs of copper and zinc with discs of cloth moistened with salt water between them.

The name galvanic will nevertheless persist as a term for the medical direct current, not only because of long usage but because it means *a direct current of the milliamperage useful in surgical or medical practice*, and with *a voltage only sufficient to carry the desired milliamperage through the human tissues.*

The galvanic current may be best understood by comparing it with a water current flowing steadily through a pipe. Power is available from either current when its kinetic or motion energy is transformed into some other form of power by a suitable

mechanism, this mechanism causing the change by interposing resistance to the flow. The water current, impinging on the resistance vanes of a wheel, turn it, and its energy is thus changed to another form. The electric current turns a wheel also when its energy is first transformed into magnetism and then into motion.

Why Electricity Flows in a Current.—Water flows in a current down hill because of the gravitational attraction of the earth, the energy developed, when the current is confined during transit being available for transformation into other forms of power.

Electricity flows also "down hill," from the negative pole (cathode) in a generator at which it has been heaped up by some force (whether a dynamo, chemical action in a primary or secondary cell, or inductive force) to the deficient condition at the positive pole (anode) or to the earth.

Both currents may be made to do work during the flow.

Conduction of Electric Current.—A water current is best conveyed or conducted, with its power, through a pipe with a smooth inner surface and of sufficient caliber to carry the required volume, both qualifications of the pipe indicating a minimum of frictional resistance.

An electric current is best conveyed through a wire composed of the metal molecules presenting least "specific resistance", (copper, silver, etc.) and of a caliber to carry sufficient volume.

How Electricity Flows in a Conductor.—Physicists have now apparently determined that all matter is made of electricity, an atom in repose being made up of a minute space of confined power in which a number of the smallest divisions of electricity —electrons—revolve around a central proton, similar to the solar system, the number of the electrons determining the nature of the atom. An electric current is a flow of the less firmly

attached electrons from atom to atom along a conductor, propelled by the presence of an excess at one point to a point where there is a deficiency.

The *mode of flow through a solid* conductor, such as a wire, is that given in the previous paragraph, that of electrons from atom to atom.

The *mode of flow through a watery liquid* conductor is very different from that through a metal. To begin with, water, if absolutely pure, will not conduct electricity, and its impurities, solids in solution, are not in sufficiently close contact to conduct electrons from atom to atom. But if the dissolved substance be a *binary compound*, that is, a molecule composed of two ions with opposite charges—a deficiency charge or an excess charge of electrons—an electric charge in excess of one and one half volts will overcharge an ion in a molecule, causing it to rotate and pass its excess electrons to the opposite ion of the next molecule, which by similar rotation passes its defficiency backwards, thus resulting in a forward progression of power.

This fact, that electric conduction within liquids is accomplished by chemical interchanges in binary molecules in solution, is important to physicians, for the body may be regarded as a complex solution of binary and other compounds which undergo chemical changes during the transmission of the current—changes that persist for some time when the galvanic current is used, but for exceedingly brief intervals when the current is alternating.

Electric Pressure or Voltage.—It was pointed out in a previous paragraph that a stream of electrons, an electric current, flowed "down hill" from the cathode because power had been heaped up at that point, just as water flows through a pipe from an elevated source in a reservoir, This analogy between force stored and conveyed by hydraulic currents and force stored and conveyed by electric currents may well be pursued further, for the laws of power transmission in stored and

flowing energy are really similar for all kinds of currents, and are more easily presented to our senses by the water current.

The best electrical analogy to the water current from a raised reservoir is the storage cell. This is a true reservoir of electric force that has been pumped into it. It is a low voltage reservoir of electricity. A condenser is the only other true reservoir of electricity, but one only available in practice for high voltage charges.

The storage cell consists essentially of two sets of lead plates immersed in weak sulphuric acid, each set connected with a single terminal. The plates are arranged for the greatest surface exposure to each other without those connected to opposite terminals being permitted to touch. If a direct current (or the direct waves of a rectified alternating current), is pumped in at one terminal a portion of it becomes stored in the form of lead salts on the surface of the plates and in the acid solution, the energy being heaped up in the molecules in so unstable a form that they pour it out in the form of a current in an opposite direction as soon as a path is opened through a conductor, the solution and plates then reverting more or less into their condition before charging. The energy or power was stored in chemical form.

A primary cell, on the contrary, actually generates electric current, so far as energy can be generated by anything under the general law of the conservation of force.

The primary cell generates or releases electricity held in chemical form in binary compounds in aqueous solution and in metals because of the peculiar electric relation of two metals to each other. All metals are positive or negative to each other in varying degrees. Of the list, the greatest difference exists between carbon and zinc.

When a plate of carbon and a plate of zinc are immersed in an electrolyte, (an aqueous solution of a binary compound), and

their unimmersed parts connected by a conductor, their immersed surfaces have opposite electric charges which, in the case of these two metals, are far enough apart to attract opposite ions from the solution, setting up an electrolytic action that releases electric charges stored in the chemicals, water and zinc plate, the charges pouring out as an electric current at the zinc cathode through a conductor and back in to the carbon anode as long as the path exists, until the charges stored in the electrolyte and zinc are exhausted by storage into some other forms of chemicals, now practically debris, and the current slows up or entirely ceases until the cell is recharged.

The dynamo, of both the direct current and alternating current variety, is also a true generator of electricity, under the limitations of the conservation of energy law referred to, for it extracts from the power that turns the armature the electric current in the field of the magnets, the magnetic field itself being either produced by the power applied or by that residing in permanent magnets.

MODE OF PRODUCING SUFFICIENT PRESSURE IN A GALVANIC CURRENT

A water current flowing "down hill" in a confined channel, such as a pipe, flows with an intensity or velocity proportional to the difference in level between the intake and outlet of the pipe. This difference in level rise to *pressure*, which is directly proportional to the height of the intake above the outlet. A reservoir of water forty feet high will give twice the pressure in a pipe leading to the ground as will a reservoir twenty feet high.

An electric current must also have pressure to do work, particularly to force a passage through the poorly conducting cuticle of the human body. The current of a primary cell, it has been stated, has the pressure of the difference in potential between carbon and zinc, or 1½ volts. Enlarging the plates of the cell will not increase this pressure, (though it will lessen

internal resistance), for in the end we have only the pressure inherent in a single pair of plates of these metals. The only way to increase the pressure of a current from cells is to arrange them *in series* in a battery as follows: the carbon of the first cell is connected by a wire with the zinc of the second, the carbon of the second with the zinc of the third, and so on, the unconnected first zinc becoming the negative pole or cathode of the battery, designated by the minus—sign, and the final carbon terminal becoming the positive pole or anode, designated by the plus + sign. As the pressure of each primary cell is one and a half volts the combined pressures at the poles of such a primary battery of, say, twenty-four cells will be thirty-six volts.

The pressure obtainable from a secondary or storage cell, no matter what its size, is about two volts, increased pressure being obtained as in primary cells by arranging them in series in a battery, the combined pressure being about double the number of cells in the battery or forty-eight volts for a storage battery of twenty-four cells.

The pressure of a current from a dynamo is determined by its windings and speed of revolutions.

The Unit of Pressure: The Volt.—The unit of electromotive force or pressure measurement is the volt. This is the pressure difference between the metals zinc and copper, and was adopted because the Daniel cell, a zinc and copper cell, a cell popular with the physicists at the time the unit was adopted, gave this pressure, and was a cell that could be constructed in an exact and standard form.

Resistance.—Force of any kind cannot manifest itself except by exertion to overcome resistance.

A stored force, as water in a reservoir, would not remain stored but for stoutly resisting walls. It would not carry power in a pipe unless the sides of the pipe were strong enough to resist the pressure.

A pipe line also presents resistance to the delivery of water power at the outlet, this resistance being of two kinds: First, the weight of the water being propelled, and the amount of friction presented by the lining of the pipe; and, second, the diameter of the pipe and its length. The weight and friction are self evident. The resistance due to the width of the water path and to its length are also easily understood, for the use of a path must be limited by its dimensions. It follows that doubling the diameter of the pipe, (which increases its cross section area fourfold), will lessen the resistance to one fourth. The resistance due to the length of the pipe increases directly with its length—200 feet will present double the resistance of 100 feet.

An electric current meets a resistance in a wire that is specific to the metal of which it is composed, as explained below. This specific resistance of a conductor to the passage of electrons is somewhat analogous to the frictional and weight resistances of a water current. The relation of electric resistance to the width of the path of the current and to its length is exactly analogous to the same relations of the water current. One hundred feet of annunciator wire, for instance, (No. 20 Brown & Sharpe gauge) will have a resistance of about one ohm, while 200 feet will have about two ohms.

Broadening the path of an electric current by broadening its conductor will, conversely, lessen its resistance in proportion to the broader caliber of the path.

The Unit of Resistance, The Ohm.—The measurement of electric resistance was first undertaken with galvanic currents, in measuring the current flowing in a wire conductor from one of the old primary cells. The Daniel cell, with copper and zinc elements, each surrounded by a sulphate solution of its metal, has what may be called a relatively small "internal resistance" between the plates through the solution, and this was taken as the unit of resistance and named an Ohm, from a German professor and mathematician.

All generators of electric current must of course present internal resistance, though that presented by a modern dry cell is a small fraction of an ohm, and the internal resistance of storage cells and dynamos is so small as to be negligible by physicians. To "short circuit" wires from either of the latter, by allowing metal conductors to therefore touch each other, permits such a deluge of power to escape as to endanger the melting of instruments in its path. It is like breaking down the side wall of a large reservoir of water.

All substances may be divided into those that conduct electricity with greater or less ease and those that insulate it more or less. Metals are the best conductors, probably because the molecules are best adapted to carry the electronic flow, and of these copper is usually considered as presenting the least resistance to the flow, hence it is rated as I in the comparative list, though silver is a slightly better conductor. This inherent resistance of a metal is called its "specific resistance."

Table of Specific Resistances.—Resistances in ohms of the same length and diameter of wire that would present a resistance of one ohm if composed of copper:

Silver	0.77
Gold	1.38
Aluminum	2.29
Zinc	2.82
Iron	5.36
Tin	6.76
Platinum	7.35
Lead	9.96
German Silver	10.09
Antimony	18.07
Mercury	47.48
Bismuth	64.52
Graphite	1106.00
Gas-carbon	2037.00

A clear idea of the effects of the sizes of copper wire on the resistance presented by it may be gained by scanning the following table, taken from "Practical Electrotherapeutics and Diathermy" by one of the present authors. (The Macmillan Company, New York, 1924.)

Lengths of copper wire in common use required to give a resistance of One Ohm. The numbers of the wire are those of the Brown & Sharpe gauge.

No. 40	(an extremely fine wire, rarely used)	1 foot
No. 36	(the finest wire employed as conductor for ionization electrodes)	2.3 feet
No. 32	(a fine wire, of light weight, useful for conduction of most galvanic currents)	6 "
No. 28	(the heaviest wire needed as conductor attached to active electrodes)	15 "
No. 26	(useful as a more lasting conductor attached to dispersing plates)	23 "
No. 20	(employed in annunciator and bell wiring)	100 "
No. 0	(smallest trolley overhead wire)	2 miles
No. 0000	(trunk line trolley wire)	4 "

One lesson taught by the figures in this table is the small importance of the resistance of cords and wires used for conducting and applying electric currents to the human body. No. 32 is the finest wire likely to be used as an electrode connection in ordinary applications, yet six feet of it give but an ohm resistance, while the human body between electrode pads presents hundreds of ohms and three or four thousand ohms between dry plates on the skin. Fine, or small caliber wire, will therefore carry all the current required in heavy applications, and is often preferable to heavier wire for the mechanical reasons of lightness of weight, a heavy wire often tending to pull an active electrode out of position, shocking the patient. Double cotton covering affords ample insulation for low volt currents when care is observed to keep the wire from touching moist skin.

The resistance of the human body varies greatly according to the part traversed by the current and the condition of skin contacts, dryness or moisture of the skin portals being more important than the distance traversed by the current through the body. The greatest part of the body resistance is in the cuticle itself. Muscles, glands and bloodvessels are comparatively good conductors and bone poor. Disease is said to change the resistance of the affected parts. The variation due to the cuticle and its condition of dryness or moisture is shown by the following experiments:

With small, dry metal electrodes held in the palm of each dry hand the resistance may be as high as 3000 ohms. With large, moist pads placed on the abdomen and back it may be lowered to 100 or 200 ohms. With a large metal electrode in the moist vagina and large, moist dispersing pad on the abdomen it may be reduced to 80 or 100 ohms. With large puncturing electrodes, both thrust into a vascular malignant growth and thus entirely eliminating the skin, the resistance may be reduced to 20 to 40 ohms, the distance of the electrodes apart becoming important for the first time in the experiments.

Volume or Amperage of an Electric Current.—The volume of a water current delivered by a pipe is the number of gallons passing the outlet per second from its "head" or pressure through the resistance encountered.

Similarly, the volume of an electric current is the number of amperes passing the outlet of the conductor per second from its pressure through the resistance of the conductor.

The Unit of Volume, the Ampere.—The ampere, like the volt and ohm, was adopted from the Daniel cell, being the volume of current delivered by a standard cell of this type from its pressure of one volt through its internal resistance of one ohm.

The ampere is much too large for medical purposes, therefore its thousandth part, the milliampere, is the medical unit of the direct or galvanic current as well as of high frequency currents.

CHAPTER II

GALVANIC APPARATUS

Generators—Conducting Cords—Electrodes for Low Current Voltage—Active Electrodes—Surface Electrodes.

Generators.—The physician of the present day being fortunate in obtaining the galvanic current for all office applications from the modern forms of wave generator apparatus, the discussion of cell and battery generators in preceding pages has only been necessary from a historical and informative point of view. The difficulties encountered by the pioneers in this work in securing current from batteries of chemical cells undoubtedly had much to do with the limited use of the galvanic current in the recent past.

The galvanic current should be waveless for most of the purposes described in Part I of this work, and, before the development of the generators mentioned, could only be supplied by some form of cell battery or by small direct current dynamos operated by alternating current motors, the small dynamos often giving a wavy current from an insufficient number of sectors in the commutator.

These modern generators have meters to indicate the actual galvanic current traversing the patient, with a means of turning on and off the voltage needed to secure the milliamperes desired, both voltage and milliamperes being indicated by meters. The polarity of the terminals is also marked, but the correctness of this marking should be tested before using an apparatus the first time as polarity is exceedingly important in this current.

The Conducting Cords for galvanic currents and other low volt currents need less insulation than those for high frequency and static currents, and may therefore be lighter in weight—a distinct advantage in practice. These cords are liable to have

their conducting wires broken at sharp bends and kinks if not kept hanging in a large curve from two or more hooks when not in use. Their ends should also be examined occasionally for rust or breaks that might give slight shocks to patients, and they should be connected firmly to generator and electrode when used to avoid accidental shocks.

Electrodes for Low Volt Currents.—The galvanic and low volt wave currents always require that both electrodes connected with the binding posts of the apparatus be placed on or within the body surface, one being connected with the negative pole and the other with the positive pole. They are, therefore, always bipolar, though one is usually smaller in order to concentrate the current at or near the disease, and called the active electrode, while the other is employed to complete the circuit with as little surface effect as possible, having a wide surface, and is called the dispersing or indifferent electrode.

Active Electrodes are of shapes and sizes adapted to the particular work to be done, and will be described in connection with special application and affections.

It should be stated here, however, that the nickel-plated internal electrodes appropriate to alternating current surges and other currents without chemical action should not be used for the galvanic current except as a negative pole, as the nickel or other metal surface is eroded when it is positive and the metal ions produced are driven into the tissues, complicating the application and injuring the electrode. When it is desired that no ions are to be driven into the tissues from an internal positive electrode the electrode should be of gold, platinum or carbon. As the two former are expensive a carbon ball electrode covered with moist absorbent cotton is usually employed in vaginal positive applications, unless one decides that the mercury ion is an useful adjunct to nearly all positive applications, when a copper electrode coated, (amalgamated), with quicksilver is used. This is particularly advisable in intrauterine applications,

where carbon is at times too bulky for insertion. The mercury ion is diffused mostly from such a positive pole as it is more readily diffused than the copper ion.

Surface Electrodes, both active and dispersing, should be of a size to permit no greater concentration of current per square inch of contact than is agreeable to the patient, even when the electrode is the active one, and the dispersing electrode as large as is convenient.

Until recent years the marketable surface electrodes have left much to be desired in the perfection of skin contact and the maintenance of an even thickness of pad between plate and skin, points of extreme importance in the proper and comfortable administration of low volt currents. Electrodes with pads permanently attached to the conducting plate are undesirable. Separate pads, that may be left immersed in water in a sterilizer, when not in use and kept warm as well as moist during office hours are always more satisfactory, the connecting plate with soft rubber shield being placed over it when used. If the pad is permanently attached to the plate it becomes foul from body ions and oxidation of the plate.

The material of which the surface electrode is composed is important, the desiderata being perfect contact with the skin; sufficient thickness to absorb the chemicals formed from ions precipitated on the metal plate as nascent chemicals, and thus protect the skin; and sufficient thickness to keep the plate equidistant from the skin at all points and maintain sufficient moisture and warmth during the application. These qualities are possessed in greatest measure by asbestos with a linen cover, as kaolin and other clays that fulfill the requirements are liable to pass through the cover and soil the patient's clothing and ultimately the office itself.

The sterilizer in which these pads are boiled to eliminate accumulated chemicals and kept moist and soft should have a rustproof interior. City water or well water is used, as these contain

sufficient ions to conduct the current. It should be changed frequently, particularly if the water supply be hard.

Formerly the resistance presented by the pad itself to the passage of the current was lessened by adding sodium chloride to the water. This was only excusable (when the chlorine ion was not to be diffused) when one used weak batteries or an inadequate power supply. With modern generator supply it is no longer required, as much power as needed being turned on by the controlling device of the generator saving the patient from unnecessary suffering and the plates from rusting from the chlorine developed at the negative plate. Poorly designed or rusty surface electrodes are sure to discourage a beginner in low voltage therapy, and render the finest generator useless.

Sand Bags and Shot Bags.—Bags of clean seashore sand about half the size of the large surface electrodes are very useful to hold electrodes in place as well as smaller bags partly filled with bird shot. These may be kept clean by enclosure in slip covers.

CHAPTER III

RESISTANCE

The Body as a Conductor of Galvanic and other Low Voltage Currents—the Body an Electrolytic Conductor—Diffusion and Concentration of Low Voltage Current within the Body—Distribution of Resistance in Body Circuit—Area of Electrode Contacts.

The Body an Electrolytic Conductor.—Regarded as a conductor of electricity of moderate pressure the human body is a broad conductor composed of varying concentrations of electrolytes in solution enclosed within a partially conducting envelope, the more horny layers of the skin. For the current to reach the better conducting interior it must pierce the poorly conducting sheath, the skin, which nature has apparently designed as a protecting covering. The total resistance through two layers of the skin, as between metal discs on the dry skin of the palm and the dry skin of the sole of the foot, may be as great as 4000 ohms when the contact plates are small. Changing to broader plates with moist pads blotting out the small layer of air between the metals and skin, and using a skin area that has more ions in it, as sweat gland openings, the resistance may be lowered to one or two hundred ohms. If the skin be eliminated entirely by broad contact needles thrust into a malignant growth the resistance will be lowered still further to fifty or even forty ohms. Surface electrodes are therefore important portals for current to the inner part of the body through a difficult territory, and too much attention cannot be paid to their appropriate area and technical qualities.

Diffusion and Concentration of Low Voltage Current Within the Body.—A low voltage current tends to spread out and fill a broad conductor, at its point of entrance, reconcentrating its *lines of flow* at the point of exit. This occurs in

the human tissues after the penetration of the skin or mucous membrane. Since the energy effects on tissues depend on the concentration of these lines of flow, our ability to carry effective concentrations to deeper parts is decreased by this spread, and must be compensated by increased milliamperage.

Distribution of Resistance in Body Circuits.—The ideal concentrations and diffusions of the lines of flow shown, are actually altered by the differing resistances of the various tissues traversed as well as by the skin.

Since the work is done by a current in any given organ in its path, its expenditure of energy is proportional to the resistance encountered, as well as to the number of lines of flow through the organ. There will be an unequal distribution of action in deeper parts that is not entirely explained by their density.

Area of Electrode Contacts.—Since all the lines of flow entering and leaving the body must pass through the portals of electrode contacts, and their local effect on skin or mucous membrane is proportional to their density at these points, the importance of electrode contact surfaces in relation to dosage is evident. This is particularly true at the active pole, where concentration is needed for local action or to reach deeper parts with effective dosage. A ten milliampere current, for instance, is twice as concentrated and twice as locally active on an actual contact of one square inch as on a contact of two square inches.

Conversely, when we select a dispersing pad to merely complete the circuit with as little local action as possible, we should select one as large as practicable.

CHAPTER IV

CHEMICAL EFFECTS OF THE GALVANIC CURRENT

Electrolysis—Electrolysis of Living Tissues—Polar Regions—Deposit of Foreign Ions Within Polar Regions—The Interpolar Region.

In considering how we are to influence living processes within the body by passing a galvanic current through it, we should recall that this composite electrolyte is throughout life the seat of innumerable dissociations and reassociations of the molecules of which it is made up and which are fed into and drained from it: that these changes are a part of life itself, and their proper action essential to health. Each such dissociation and reassociation is accompanied by electric phenomena.

The several organs, moreover, release currents of small voltage and small amperage by this action that flow in definite circuits, the wattage varying with the functional activity of the organs—all of which is taught in the physiologic laboratories of the medical colleges. We also have those variations in the prevailing acid and alkaline conditions of the body as a whole that have frequently been studied by physiologic chemists.

To introduce into this microcosm of molecular changes, in which gentle currents of electricity are being wafted in definite circuits a much greater current from without—a current of the same nature, yet differing as a hurricane differs from the gentle breezes of the countryside, must have alterative effects of a definite local character that are capable of remedial use. Such effects are found only with the galvanic current.

These effects of the galvanic current differ in *nature* at the polar portals of entrance and departure, and also in *concentration* at the poles and in the interpolar region. The effect of concentration and diffusion have been described in the previous paragraphs.

The action of the poles will be best understood after a statement of the phenomena of electrolysis.

Electrolysis.—The direct or galvanic current differs from other medical and surgical currents in producing a definite chemical change in the body during the whole time of its passage, due to the persistence of the molecular changes by which it is conducted through the body electrolyte; the other currents, while producing chemical changes in proportion to their wattage, have either *so slight a change*,(static), or the change, while great, is *so quickly reversed back and forth*, (alternating currents, high frequency current), as to be unable to indicate its presence biologically or chemically.

The chemical change produced by a static current, (which is a true direct current, though differing so greatly from the galvanic in voltage, milliamperage and continuousness), can be easily detected by the wet litmus paper test described on page 24 when the generator is producing a full charge.

Apply this test, or the potassium iodide test, on the other hand, with an alternating or high frequency current: No gas evolution will occur at either pole and no color will appear at the positive. Both these currents are also carried through the body by ionic changes in molecules, but the changes are too brief to produce chemical reactions that will register on our senses.

Electrolysis of Living Tissues.—The term electrolysis in its medical applications should be restricted to the surgical minor operation in which the dissociation of tissue accomplished physical destruction of it at one or the other pole by sufficient concentration of the lines of flow at a small electrode contact, whether it be the great concentration of a small current at the tip of a fine needle, as in the epilation of a hair or the destruction of a mole by the negative needle, or the concentration of massive currents to comparatively small electrodes to coagulate tumors by the direct current. In either case we have a true electrolysis or electric dissolution of tissue.

When we apply the galvanic current medically, on the other hand, by dispersion of the lines of flow by broad electrodes at the surface contacts and the arrest of the nascent chemicals appearing at the metal plates by thick pads, we achieve an equal dissociation and reassociation within the body electrolyte, but *without destructive polar effects*. Medical applications of this current should therefore be regarded, not as electrolysis, but as possessing chemical effects not necessarily destructive.

Polar Regions.—For some distance beneath each pole the galvanic current presents different chemical concentrations due to electrolytic conduction, the depth to which they extend being determined by the wattage and duration of the current. Alkaline ions accumulate in the region beneath the negative pole and acid ions in that beneath the positive pole, *both giving up their electric charges on reaching the metal plate of the electrode and becoming nascent atoms*. This is evident to the eye when pointed metal electrodes are inserted into a malignant growth in a major operation of direct current coagulation, and may be described as follows:

At the negative pole, with a current of 250 to 1000 milliamperes, the effect shows in a few moments as a semi-translucent infiltration of alkaline bases and hydrogen gas in immediate contact with the metal, accompanied in a few minutes by the issuance of a highly alkaline froth, which soon becomes greenish in color from the bases of hemoglobin etc. and so abundant that it has to be wiped away to keep the field of operation in sight. This froth is composed of the watery components of the tissues and vessels of the growth and hydrogen gas, water being abstracted from the tissues at the negative pole, the tissue bases giving it a soapy character. If the current be increased above 1000 milliamperes the tissues will shortly become dissolved about this electrode and it may fall out, or pull out if a hook.

At the positive electrode, *if the electrode be an unattachable metal,* a retracted, dry, horny area will show itself less quickly around the electrode in such an operation. If the area of con-

tact of the electrode is small the tissue immediately about it will become drier by its watery contents being driven in, and as this increases the resistance the current will fall at the meter and more voltage will have to be turned on at the controller. If moisture is found next the instrument its reaction will be acid. *If the positive electrode be composed of zinc*, as in these operations, the retracted tissues around the electrode will soon show a dense white coloration that extends towards the negative pole and ultimately meets the negative region, leaving the intervening tissue completely devitalized. This white area is composed of zinc eroded from the electrode by the attacking oxygen and chlorine of the dissociated tissue and fluids, the zinc ions when eroded from the zinc electrode being driven from the latter into molecular union with an ever spreading zone of acid tissue ions along the lines of flow to the opposite pole.

Considering for the moment only the polar effects occuring when both electrodes are of unattachable metal, as described in the first part of the preceding paragraph, it is evident that the alkaline reaction at the negative pole and the acid reaction at the positive are due to the ions of body molecules driven to the poles by the current.

A similar alkaline concentration is found in the negative polar region beneath a negative electrode in a medical galvanic application, and an acid concentration beneath the positive electrode, both concentrations being of body ions.

The *depth* of these concentrations depends on the voltage and duration of the current and its *density* on the milliamperage.

Deposit of Foreign Ions within Polar Regions.—In an ordinary galvanic application the current is conducted through the moisture of its electrode pads by the earthy and other salts in ordinary water, there being therefore a diffusion into the body of ions from the electrode pads in these applications.

If the electrode pad is freed from impurities and impregnated with a drug composed of a binary molecule dissolved in distilled

water, the action ion of the molecule is driven into the polar region beneath the proper electrode and the inactive ion backwards against the plate of the electrode. This constitutes medicinal ionization.

Surgical ionization occurs when the ion of a caustic molecule, as zinc, copper, silver, etc., is driven in, as illustrated in the operation described above. Such a molecule may be eroded from the metal or dissociated from a solution of a salt of the metal in contact with it.

The Interpolar Region.—It is evident from the preceding statements that a flow of ions takes place throughout the circuit of equal speed and amount, but that the concentration of these changes must be slight in the broad, divergent paths deep within the body unless powerful amperage is used. Moreover, these changes are ionic—not atomic, with consequent absence of the possibility of direct medication within deep tissues. Forced ionic changes within and between organs may, nevertheless, have remedial action.

The question of the action deep within the interpolar region of an abrupt wave of galvanic or other current is different. If we can carry an abrupt wave of even a half a milliampere concentrated in a half inch cross section of an intestinal muscle or abdominal gland, as can probably be done when 100 or 200 milliamperes are driven through the skin, there is no possible doubt of deep muscle or neuron response.

CHAPTER V.

THERAPEUTIC ACTION OF GALVANIC POLES

Identification of Polarity—Importance of Selection of Pole—Differential effects of poles—Action on Special Senses—Reflex Stimulation of Neurons by Galvanic Waves.

Identification of Polarity—Connect a conducting cord or piece of wire of convenient length to each binding post of the generator and, carefully keeping the other bare ends of the wire from touching each other and thus short-circuiting the apparatus, dip them in a glass of water in which a teaspoonful of table salt has been dissolved, holding the ends about two inches apart in the water. Upon turning the current on the saline solution will be freely electrolysed and an abundance of gas will form at the negative pole, (hydrogen), while less will appear, (oxygen), at the positive pole. The difference in amounts of gas will readily identify the polarity.

Or, if doubtful, drop a little potassium iodide into the solution: a brown coloration of free iodine will appear at the positive pole.

Or, pass the current through the length of a wet strip of litmus paper lying on glass or other non-conducting surface: a blue color will appear at the positive pole.

Vital Importance of Selection of Pole in Galvanic Applications.—The practical importance of selecting the proper galvanic pole for the active electrode is even greater than would seem evident from the facts stated in the previous chapter, for a wrong selection may not only defeat the object of treatment but aggravate the condition to be relieved. Probably the strongest illustration of this is a mistaken or accidental use of the negative pole within the uterine cavity to control hemorrhage. While any non-menstrual bleeding may be checked at once by the appropriate use of the positive pole and its recurrence prevented

by repetitions of the application, the use of the negative pole would increase the flow instantly, and if no other harm was done, might lead to loss of the patients' confidence and thus failure of a relief that could be absolutely predicated on the proper application. In the field of purely medical effects, lack of accuracy of selection would produce an acid concentration when an alkaline concentration might be more effective, and vice versa.

The medical differences in the relief of pain are very great. *The positive pole tends to relieve pain* if the painful spot can be brought within this polar region, possibly by a drying effect, or possibly by its chemical action. *The negative pole is likely to aggravate pain* if the seat of pain can be brought within its polar concentration.

The surgical relations of the two poles to pain correspond to their medical effects. In other words, a current of a half a milliampere or more, concentrated on the point of a needle in the skin or mucous membrane, is always more painful when negative than when positive. When polarity is not important in minor galvano-surgery, (though it usually is very important), one may apply a minute surgical concentration of the positive pole with far less pain than with the negative.

Direct Polar Effects of Galvanic Currents. — Stated succinctly, therefore, the positive pole arrests hemorrhage by producing an acid coagulation and a drying effect; produces vasoconstriction: is sedative to sensory nerve endings and thus relieves pain; and when concentrated surgically produces an acid eschar.

The negative pole produces hyperemia and stimulation of tissue by attracting water from the tissues; causes vasodilation; aggravates pain and is irritating; and when concentrated surgically produces an alkaline softening and dissolution of tissue rather than an eschar.

An important polar action of the galvanic current is its wave action, which will be discussed more fully in Chapter VII.

When thrown into waves this current surpasses all others in forceful stimulation of motor neurons and muscles, the stimulation differing at each pole, alternating waves being nevertheless often preferable because less painful and without the chemical effects of the galvanic. In some instances, as in Wallerian degeneration of muscle, this added and differing wave effect is useful in causing contractions of muscles when waves of less duration and bulk are ineffective.

A most interesting and too often neglected action of these polar concentrations, particularly in waves, is that on the terminal organs of special sense. Alone among electric currents, the galvanic, either waveless or in waves, will cause responses in these nerves, producing the electric flash in the retina, electric sounds in the auditory mechanism, electric odors in the olfactory nerve and electric taste in the gustatory nerve—all with an exceedingly small milliamperage traversing the nerves, and each response differing with the polarity.

A fact of equally great, if not greater importance than the direct stimulation of the nerve terminals of special sense by this current is the reflex stimulation of these organs that is possible with this current and with heavy amperage alternating waves. The application of a weak galvanic wave to any part supplied by the fifth nerve will cause the electric flash, and a heavier current will produce the flash when applied as far away as the neck or even the shoulder. That this response is reflex and not due to a direct transmission through the retina or optic nerve has been determined by us. We failed to obtain the flash in a patient with anesthesia of the skin of the forehead when both poles were confined to the anesthetized area. Moving either electrode beyond the area brought instant flashes.

The therapeutic possibilities of this reflex stimulation with slow and bulky waves indicates their use in stimulating the neurons of abdominal glands that are too deeply situated to be readily brought under polar influences.

CHAPTER VI

THERAPEUTIC USES OF THE CONSTANT OR WAVELESS GALVANIC CURRENT

Two Remedies in Galvanism—Waveless Galvanic Currents—Choice between Galvanism and Diathermy—Medical Galvanic Applications without Medicinal Ions.

In the galvanic current the physician has two widely differing remedies, even from the purely medical point of view: the waveless current and the wave current. Conditions in a given case, such as an atrophied muscle after Wallerian degeneration, may indicate the value of both—that a galvanic wave as well as the negative polar action is indicated. But when greatest galvanic action uninfluenced by waves is needed, as in deep polar acid or alkaline concentrations within tissues or deep polar diffusion of drugs, it is extremely undesirable to have any waves or other sudden variations of the current, *because the added pain will limit the amount of the dose or its duration.*

Waveless Galvanic Applications.—In all waveless galvanic applications, therefore, the generator should produce a smooth current; the conducting cords should be tightly attached at both ends and not subjected to movements that might break their connections; the electrodes should be in place before the current is turned on, this being rendered certain by a glance at the controlling device before placing them to see that no current is turned on; and with everything in place, the current is turned on very slowly until only a part of the dose is indicated at the meter, taking often three to five minutes to reach the maximum. On the completion of the application, the current is turned off fully as slowly as it was turned on, any change giving rise to some discomfort.

Choice Between Galvanism and Diathermy.—This current, as pointed out, differs greatly from other methods and its

indications are usually definite. Yet there will be at times a difficulty in choosing between it, when waveless, and diathermy, in conditions indicating the value of hyperemia; for, though heat production is neglible with the galvanic currents used in medicine, (direct current surgery using far more power and concentration), the chemicals and water accumulating in the negative polar region cause pronounced hyperemia. But this negative pole galvanic hyperemia is superficial compared with the deep heating action of diathermy. The choice should be largely governed by this fact, together with the possibility of a remedial effect within this deep region from the ionic changes in the interpolar region.

This choice between diathermy and galvanism is sometimes best decided by using both, the galvanic effects being helped by a previous diathermy application.

Medical Galvanic Applications Without Medicinal Ions. Straight Galvanism.—The medical conditions in which the modern physician turns to diathermy have in great part been treated by the older physiotherapists for years by waveless galvanism, often with pronounced success in spite of handicaps of armamentarium, now happily past. These were conditions in which an increased local metabolism seemed to be indicated, such as post-traumatisms, chronic neuritis, the arthroses, etc. In such applications at present one is tempted to add a suitable drug to the appropriate electrode, in spite of the opinion of an eminent English authority, Major Turrell, that it is the galvanic effect that yields results rather than the drug when the latter is used.

A mode of action that may also influence therapeutic results is that of counter-irritation at the surface and beneath either electrode, particularly the negative. This effect is limited to this current among electric methods.

The use of the waveless galvanic current without drugs in the conditions mentioned will commend itself to the office

practitioner for several reasons: the commercial surface electrodes may be used with the plain galvanic current but are not well adapted to drug diffusion; a treatment that is time-consuming, capable of explicit prescription and demands many repetitions may be turned over to the trained assistant when these electrodes are used; and the presence of simple ions rather than drug ions in the pads is less likely to cause skin irritation.

Though the commercial electrode, with pliant waterproof cover is particularly convenient in these applications, there is no less need than in drug diffusion for a sufficient thickness of pad to retain moisture and protect the skin from the chemicals that are precipitated on the metal backing, the thickness also serving to keep the plate equidistant from the skin. The local polar bath is particularly well adapted to galvanism when it can be used, as with the elbow or an extremity, and the conducting plates in the bath kept equidistant from the skin.

A variable problem is that of maintaining a good contact of the pads to contours, and to surfaces where gravity will not keep them in contact. They may be held in position by a cotton elastic bandage, though this will become wet and conduct the current itself.

Since all prolonged applications should be made with the patient recumbent on a couch or otherwise placed for comfort and to relieve muscle strain, one may often adopt the following procedure: Place a soft sand bag beneath the part, if a limb or shoulder joint, with the larger surface electrode on it, permitting better adaptation to curves, then apply the active surface pad on the upper side of the part with a shot bag over it.

Though commercial surface electrodes when properly made and kept sterile in a rustless container are the most convenient for this work, one should not make the mistake of using too small an electrode. The active electrode, if one is to be active should have a superficial area somewhat greater than the part to be brought under its polar influence, while the indifferent

electrode should be large enough, compared with the active, for the patient to detect little or no sensation from it.

Whether one should place the dispersing or indifferent pad on the opposite side of a part or on a distant skin surface depends on circumstances. In a joint the deepest and most direct passage of the lines of flow, occurs with the electrodes on opposite sides. Where a polarity effect is desired the other polarity should be removed to a distant and preferably opposite skin surface.

A review of the immense literature relating to the value of straight galvanism in particular diseases is confusing for two reasons: First, the development of greatly improved diagnoses of diseases and more accurate knowledge of their pathology and etiology during recent years has explained many weary hours in electrotherapeutic clinics devoted to nervous diseases in particular—weary because of deferred hopes in spite of occasional successes.

Secondly, it is now evident that most of the technic of the past, with its small surface electrodes of imperfect materials and construction, was nearly if not quite as defective as the uncertain batteries, meterless current, and the absence of electric units then unavoidable.

These inherent faults were rather added to in the older literature by attempts to specify the exact technic in each particular disease. A simpler and more instructive plan, and one followed in the present work, is to consider a method as one would consider a drug—its proper actions and their indications, and the best forms of administration, in order that the intelligent physician may use it to meet his problems.

The consideration of a method in the same manner as a drug, as, for instance, arsenic in syphilis or digitalis in myocardial weakness, indicates that *dosage* is essential to effective action. Dosage in galvanic currents includes proper surface electrodes,

sufficient milliamperage and sufficient duration and frequency of repetition of applications; and the subject can be lifted from empiricism only by this full attention to adequate power for the work to be done. It took many years to learn how to run a street car with electricity, adequate power being the most important factor.

We are convinced that adherence to proper technic will open new and greater possibilities to these chemical currents.

The technic of percutaneous applications of the galvanic current applies largely to low volt wave currents, and the tendency among physicians to apply more than one method during a treatment is readily followed by leaving surface electrodes in place after a galvanic treatment and turning an alternating wave current on, the proper surface electrodes being the same; or, after one form of treatment with both electrodes on the surface, an appropriate vaginal or rectal electrode is submitted for one and a vagino-abdominal or recto-abdominal application made. Wave currents after galvanic applications are, of course only indicated when contractile tissues are under treatment.

The technic of special applications to various internal parts of the body is given in Chapters XIII and XVI.

CHAPTER VII

DIFFUSION OF DRUGS WITHIN POLAR REGIONS

Uses of Ionization—Molecules and Ions—Strength of Solutions of Drugs for Diffusion—Purity of Solution Essential—Technic of Ionization—Selection of Pole—Reported Therapeutic Value of Iodine Ion—Mercury Ion—Chlorine Ion—Cocaine Ion—Salicylic Ion—Quinine Ion.

An important use of the galvanic current, and one confined to it alone among physiotherapeutic methods, (for the only other unidirectional current, the static, has insufficient volume), is the local administration of a drug by it, with a threefold purpose: 1, to merely add to the possible effectiveness of the straight current, as in driving chlorine into the negative polar region in promoting absorption of scar tissue; 2, to flood a polar region with a drug in its ionic state with the hope that a concentration of its molecules may be secured in that region that would require huge quantities to equal if administered by mouth; and, 3, to produce a more profound action of a drug on a part within a polar region by reason of the fact that it forces a drug into immediate union with the protoplasm of the cells, instead of the slower osmotic penetration from the bloodvessels and lymphatic spaces. A demonstrated result of this more intimate union of drug and protoplasm in the case of cocaine, according to Leduc, is a more prolonged anesthesia, as absorption into the general circulation is delayed longer than after hypodermic injection.

An immense stimulus was given to this method of local administration of drugs recently by Prof. Stephane Leduc, of the School of Medicine at Nantes, France, whose accurate chemical and biophysical deductions and laboratory and clinical experiments are most illuminating and valuable. His work has been fully corroborated by others, particularly the late Sir Lewis Jones, though qualified by certain drawbacks and disadvantages mentioned on following page.

Amount of Drug Diffused.—The amount of the drug diffused is exactly proportional to its atomic weight and the millicoulombs, (milliamperes multiplied by the seconds of flow) of the current. The stronger the current, therefore, and the longer its duration the more of the drug and the deeper it is diffused. With a drug whose active ion is irritating to integument our ability to diffuse it to any depth beneath the integument is governed by our ability to protect the skin or mucous membrane from undue irritation by careful technic and by removing excess solution from the skin by an oil or cold cream after treatment, some of the latter being left on the part in anticipation of the next application.

Another fact that lessens the depth and concentration to which we may flood a region with a drug is the activity of the circulation in the part treated, as pointed out by Turrell, the peripheries of the polar region and the polar region itself being continuously robbed of the drug during and after the application.

In spite of these drawbacks, the diffusion of certain medicinal drugs directly into a polar region beneath or beyond the electrode appropriate to it has some exceedingly valuable uses in medicine, and will doubtless be extended intelligently beyond its present vogue when its advantages and limitations are more generally understood.

An even more important use of the method is the employment of the caustic and sterilizing metal ions in minor surgical procedures. These are of very great value in such conditions as surgical tuberculosis, we believing it to be almost a specific in stubborn sinuses and ulcers.

Molecules and Ions.—The physician unfamiliar with the latest views of electrochemistry should not turn from the subject of ions as too recondite for a busy man. It is a part of every dose of medicine he orders, no matter how taken, for if his medicament is a binary compound, (and nearly all are), it is dissociated in part by the very water in which it is dissolved, or by the watery fluids of the body if administered in pill or powder

and dissolved in the stomach, and the action of the medicine is governed by the number of atoms in its active ion. Bromides, for instance, owe their activity to the bromine ion, which separates from the potassium ion with which it is usually united when it is dissociated by water or the current and unites with nerve protoplasm within the body. The reason why some other salts of bromine are slightly more active than the potassium bromide is that they hold more bromine atoms to the ion.

Binary drugs doubtless circulate through the body as ions however administered, protected by their traveling charge of electricity from displaying their nascent characters until they meet the opposite ion affinity, union with which gives their special medical response.

One of the simplest illustrations of the interesting fact that an ion may travel through a solution of molecules with which it readily unites without showing the usual chemical sign of nascent union with them *while possessed of an electric charge* is shown in the following experiment with iodine and a solution of hydrated starch:

Place some recently cooked, thin flour paste in such a non-conducting utensil as an enameled ware pus basin, to the depth of nearly an inch and dip into each end of the paste a metal plate connected with opposite poles of a galvanic generator, seeing that each plate makes good contact with the paste and that they are about four inches apart.

Drop two or three drops of tincture of iodine in the paste immediately at the negative pole. The iodine will make a pool of a densely blue color by union with the starch. Now turn on a current of fifteen or twenty milliamperes.

In three minutes after the current is turned on a blue spot will appear on the point of the positive plate nearest the opposite plate, *without any appearance of color in the four inches of starch solution between the plates.* In five minutes the spot will increase to the size of a pea with this amount of current, and in twenty

minutes the whole edge of the positive plate will show blue spots without the intervening interpolar region showing color. Since the current itself is carried by the various ions in the paste, the new ions in it will gradually reduce its resistance and the milliamperage will gradually increase during the experiment without change in the controller.

As has been described, where the positive pole for the purpose of difusing drug solutions is indicated. Carbon, Gold, or Platinum must be used to prevent local oxidation and thus inhibit the action. Fig. 1 is an electrode for the purpose, having carbon within its circular treatment surface, surrounded by a ring of soft rubber; absorbent cotton is generally used saturated with drug to be applied.

It may also be adapted for a Cataphoric application with the negative pole if the surface of the electrode is sufficiently large for the case at hand.

Fig. 1

Cataphoric Electrode

We do not ionize a drug by the current. Dissociation of its molecules into ions is done in part and made easy in the remainder by *mere solution in water*, as previously remarked. What the galvanic current does is to drive the free ions forward or backward in its path and force the freeing of others and their similar passage forward or backward, according to their charges, which are always of opposite sign to the pole that they are driven towards.

Ions are *simple* and *complex*, a simple ion being one made up of a single element, as iodine in iodide of potassium. A complex ion is composed of a number of elements in chemical union, as the cocaine ion in hydrochlorate of cocaine and the quinine ion in sulphate of quinine. The latter retain their special composition in ionization diffusion and are not decomposed by the current into their ultimate elements.

Strengths of Drug Solutions for Ionization.—The amount of a drug that we can drive into its appropriate polar region will not be increased by using a strong solution but rather the contrary, beyond 1 or 2 percent. The number of ions driven in is determined by the milliamperage and its duration, and their depth by the voltage speed of the particular ion and the current duration. The amount of dilution of a drug rather facilitates its diffusion, as the drug molecules are more thoroughly surrounded by the solvent. Percentage accuracy of solutions is therefore unnecessary within reasonable limits. Approximate solutions of 1 per cent. or about 5 grains to the ounce, will serve for all medicinal diffusions.

Purity of Solution Essential.—The drug should be dissolved in distilled water, now readily obtainable since widely sold for dilution of the solution in automobile batteries, water from water pipes containing enough ions to materially reduce the number of medicinal ions diffused by replacing them.

Technic of Ionization.—The technical details are practically the same for all drug diffusions, save for selection of the proper pole for the drug and fitting the active pad to curved and internal surfaces.

If the local electrode bath is practicable, the solution may be used many times, or until considerable debris of ions extracted from the body collects at the bottom, when it should be renewed. When the active electrode is positive, plates dipping into the solution should be of carbon, though aluminum may be used as it is but slightly attacked at this pole, (being more attackable by alkalies), and the ions from it are harmless.

As remarked in a previous paragraph, commercial asbestos pads may be used for drug diffusion, but they should be separable from their plates, boiled fairly free from other ions, and dedicated for use in the special case until re-boiled for other use. For complete impregnation with the drug solution it should be dried out after boiling.

Occasionally a more perfect contact with the skin may be secured when the latter is sensitive by a thin muslin pad made to the shape of the surface and filled with kaolin or asbestos. Such a pad should be kept moist and soft in a non-corrodible receptacle between applications, and warmed and supplied with additional solution when next used, complete saturation being maintained during treatment by additional solution from a dropper.

Finally, a thick absorbent cotton pad may be used, this requiring more weight to maintain in position, or a bandage, and as more solution drips from it than from the pads described above, the dropper should be used more frequently.

The *conducting plate* laid over either kind of pad should be of tin or tin-covered lead, and it will adhere to the two first pads described. A light-weight fine wire conductor may be attached to it by threading the wire through pin holes in the corner of the plate and turning the latter over the wire several times, making a shockless joint. Lack of weight in the conductor lessens the chance of accidental displacement of the plate and consequent shocks. The conducting plate should always be smaller than the pad to prevent a concentration of the current around the edges of the pad.

The current is turned on slowly, taking five or even ten minutes to reach the maximum dose to be applied, the latter being dictated usually by the patient's comfort. At the completion of the diffusion the current is turned off even more slowly than it was turned on, especially when the positive pole is on or near the head or neck, as vertigo is easily produced by variation of positive polarity near the ear.

The duration of a drug diffusion should not be less than thirty minutes, as time must be allowed for sufficient extension of the diffusion in a polar zone to reach the tissues with which the ions are to unite. Increasing the milliamperage will increase the number of ions diffused but will not materially hasten their penetration, time being essential, each particular ion having its own speed within an electrolyte, hydrogen being the most rapid.

Selection of Pole from which to Diffuse a Given Drug.—A consideration of the chemical relations of the medicinally active ion will determine the pole under which it should be diffused. Basal ions of a molecule, such as metals and alkaline bases, and alkaloids, as cocaine and quinine in their salts, are diffused from the positive pole. Acid and halogen ions are diffused from the negative pole, as the salicylic ion from salicylate of sodium; the chlorine ion from chloride of sodium and the iodine ion from iodide of potassium or from mere solution in water.

REPORTED THERAPEUTIC VALUE OF A FEW MEDICINAL IONS.

Iodine Ion, (diffused from the negative pole).—The ready penetration of the skin or mucous membrane by an alcoholic solution of iodine merely painted on the skin or membrane, without an electric current of any kind, is a familiar fact to clinicians. A drawback is the irritation caused by a concentrated solution, preventing repetition of the application. When

the object is the treatment of a condition a short distance beneath the electrode, such as an adolescent goiter, an equal or greater penetration may be secured from a 1 per cent. solution of a salt of the metal under the negative pole, with somewhat less irritation, permitting repetition as often as every other day.

Chlorine Ion, (diffused from the negative pole.)—Whenever the negative pole of the galvanic current is used with a pad moistened with ordinary water some chlorine ions are surely diffused into the body from the chlorides held in solution. The value of the negative pole in promoting absorption of sclerosed tissue has long been known, and is apparently increased when a little table salt is added to the water of the electrode, yielding a full supply of the ion. Leduc, in the work cited, gave such striking proof the *sclerolytic effect* of the chlorine ion that it was largely employed in the physiotherapy departments of the hospitals during and after the late World War. The sharp burning sensation in the skin under the negative pole is largely due to the chlorine ion.

Cocaine Ion, (diffused from the positive pole).—Anesthesia can be produced in the skin in five minutes by the cocaine ion from a weak solution and in less time in the mucous membrane, and is said to last longer than when administered in any other way. Too long an application is said to produce a brown discoloration of the skin. The chief experience of the authors with this ion is in lessening the pain of zinc-mercury ionizations of sinuses, when the burning sensation of the zinc ion at the skin opening of the sinus can be practically banished by sprinkling a small amount of cocaine flakes on it before inserting the electrode.

The Salicylic Ion, (diffused from the negative pole.)—The salicylic ion is reported to have given good results in skin affections, dry pleurisy and chronic rheumatic conditions, the latter limited of course by the moderate extension of the polar region with currents of ordinary strength and duration. It has but

slight irritating qualities and may therefore be frequently repeated, making it possible to relieve the stomach from some of the discomfort of this drug.

The Quinine Ion, (diffused from the positive pole.)—This drug, when diffused locally as an ion, has recently received prominent mention as a remedy for persistent neuralgia of the referred type, particularly trigeminal neuralgia; and has even been of service in that most painful and usually incurable local form of the latter, *tic douloreux*, after operation had failed to permanently relieve the pain.

While trigeminal neuralgia has been relieved by several electric methods, true tic douloreux seems to be made worse by any treatment that produces heat or hyperemia, usually bringing on an attack. Prof. Bergonie, of Bordeaux, France, recently a victim of his early work with the X-ray, and some other French and Viennese physicians announced some thirty years ago the relief of this condition with the plain galvanic positive pole, giving as much as 60 to 80 milliamperes for half an hour. It is impossible that such a strong and long application might actually carry the polar region to the reputed site of the disease in the Gasserian ganglion, but we should remind ourselves here that clinical evidence is safer than speculation, and that we do not really know the pathology of this disease.

For application to the face the patient should lie on a couch or reclining chair with head rest, with a large dispersing pad beneath the back. A soft pad of asbestos or kaolin in thin muslin is made to fit the affected side of the face, if all branches of the nerve are affected the pad being in the shape of the letter E, with openings for the eye and mouth, over which is laid a smaller plate of thin tin or aluminum of the same shape with lightweight conducting wire attached. Gravity and adhesion should keep this electrode in place, but it may be held by a bandage. The pad is fully saturated with a 1 per cent. solution of bisulphate of quinine in distilled water, and it is kept saturated during the treatment by adding the solution with a dropper.

When the application is made to the affected mucous membrane within the mouth, as is wise at times, the patient may sit in a comfortable chair with a loop of gold or aluminum wire heavily covered with absorbent cotton saturated with the solution as active electrode, the part of the wire passing through the lips being covered by fused sealing wax or thin rubber tubing. The lips may be oiled to prevent undue action on them.

The absolutely waveless current is turned on slowly, on account of the hyperesthesia usually present and because of the proximity of the ear, and as slowly turned off at the end of the application. Effective current strengths seem to vary from 5 to 15 milliamperes for not less than thirty minutes.

The Lithium Ion, (diffused from the positive pole).—Thomas A. Edison directed some experiments on the diffusion of lithium in *gout,* under medical supervision, some years ago, the gouty member being placed in a bath of a lithium salt that was connected with the positive pole with the other member in a salt water negative bath. A prolonged course of the treatments ameliorated the condition.

Several European physicians have used the method, with a current as great as 200 milliamperes. One of these, Bordier, analyzed the sediment remaining in the active bath after it had been used a number of times, finding uric acid.

The Magnesium Ion, (diffused from the positive pole)—This ion is driven in from solutions of magnesium sulphate. So far as the authors are aware it has been used only for the *multiple warts on the skin* of the hand common in children, but judging from the recent practice of employing solutions of Epsom salts externally for the relief of pain, there may be a wider field for its ionic use.

In the treatment of the variety of warts alluded to a single application may be effective, the usual tenderness being allayed and the warts being left to disappear by attrition and exfoliation

when the hands are washed, no trace being found after several weeks. The palmar surface of the hand is laid on a negative pad and pad of absorbent cotton containing the solution over the warts, including them all under its surface if possible.

The Mercury Ion, (diffused from the positive pole.)—The authors are not aware of any experiments with the mercury ion in the treatment of *syphilis*, but the advantage of driving in this drug from one of its salts by some arrangement of bath electrodes is evident, when compared with attempts to cause its absorption by the skin while associated with an oil.

To add a sterilizing effect, as well as lubrication after the application, of a positive electrode to an infected endometrium and for the destruction of infection in sluggish wounds; daily applications may be necessary until the cavity heals. To destroy tuberculous foci by direct diffusion into the focus of the drug in its nascent state, this and the previous object are obtained by using copper or zinc probes coated with quick silver as the positive pole within the cavities.

The mercury ion is usually associated with copper or zinc ions in the office applications mentioned above by being diffused from copper or zinc electrodes coated with the mercury, more mercury ions being diffused by the current than the other ions, particularly copper, as the mercury is more attackable. Pure mercury, diffused from a gold electrode, as ascertained in a long series of applications by us, is not especially cauterant and only slightly destructive of tissue, and has a value as predominantly sterilizing rather than destructive in such applications as in the local treatment of *trachoma* with an amalgamated gold needle. When diffused from an 18 karat gold electrode the mercury alone is diffused, after the alloys on the surface of the gold have been diffused with the mercury. All the mercury on a gold electrode may be driven in if a heavy current is used for a moderately long time, leaving a pure, yellow gold surface that is somewhat roughened.

A copper positive electrode with active surface about the size of the inch-and-a-half end of a Simpson uterine sound, freshly amalgamated before treatment, will lose much of the mercury after 40 milliamperes have passed through it for five or ten minutes, showing a greenish lead-colored surface.

A zinc positive electrode of the same size retains a bright quicksilver surface after a number of such applications, but the zinc will be distinctly eroded, zinc being nearly as attackable as mercury.

Copper and zinc ions have long been diffused from solutions injected into a cavity or held in a covering of cotton on the electrode, and their diffusion in this manner is often valuable when all parts of an abnormal cavity is to be reached, but injection into the uterus is unsafe, and a covered electrode too large. The quick silver coated instrument is generally best in natural cavities, the mercury preventing the sticking of the electrode after treatment as well as adding to the sterilizing action.

Amalgamation, or coating these metal electrodes with liquid mercury is accomplished with ease when the electrode is gold, merely dipping the bright gold surface causing ready covering. In fact, the instrument will probably be dissolved entirely if left in the mercury. A copper surface, if bright, will also take the metal easily, though an invisible film of oxidation may have to be removed with emery cloth at times. When tarnished it should be rubbed with emery cloth and then dipped in 10 per cent., or 25 per cent sulphuric acid and water, then into the mercury, and rubbed with a wet cloth; repeating until a bright coating is attained, when the acid is washed off.

A zinc electrode is amalgamated by the same procedure, but with much greater ease if bright. As the mercury sinks deeply into zinc and gold especially, making them extremely brittle, great care is to be used in the employment of zinc and gold coated instruments within cavities for fear of breakage.

CHAPTER VIII

CAUSTIC ION OF USE IN SURGERY

Surgical Ionization—Zinc Ion—Copper Ion—Silver Ion—Ferric Ion.

When one of the heavy metals, such as iron, silver, copper or zinc, is used as the positive pole of the galvanic current, or a salt of the metal, the metal is eroded by the tissue anions, oxygen, chlorine, phosphoric acid, etc., that reach it in the electrolytic process by which the current is carried through the body, the eroded ions of the metal then being projected from the metal into the tissues in the same manner as described for the basal ions of drugs. Unlike them, the union of these caustic ions with the tissues does not produce an absorbable molecule but devitalizes the tissue with which it unites, producing a more or less non-absorbable material which must separate, if a heavy current or one of long duration has been used, as a slough that is more or less sterile according to the ion employed. After a weak current or one of short duration the detritus separates as a serous discharge. The surgical advantages of destroying or removing tissues in this manner are: bloodlessness; the sealing of blood-vessels and lymphatic spaces at the peripheries of the destroyed tissue, thus preventing operative re-infection when dealing with infected tissue; and relative painlessness. In the surface applications for mere sterilization and stimulation without the production of a slough, the advantages are controllability of action and a deeper penetration into crypts and follicles than would occur with the drug if the current was not used.

The Zinc Ion, (diffused from the positive pole.)—This ion is the most caustic of surgical ions. It may be diffused from a 1 or 2 per cent. solution of zinc sulphate, a zinc probe making contact, with the solution, or from the metal itself. The effect of a mild current when the liquid is used is to intensify and deepen

the effect of the solution alone. The metal is used in the form of a needle or probe, and for large *indolent ulcers*, as a plate. When the lines of flow are sufficiently concentrated a densely white slough is produced, of a depth and extent governed by the current and its duration. Wounds so produced heal readily and are but slightly painful unless situated in hypersensitive locations.

The Copper Ion, (diffused from the positive pole.)—The copper ion is less destructive than zinc, and is chiefly used to sterilize and stimulate healing of *sinuses*. It produces a green deposit in the tissues that is readily thrown off in the serous flow caused by the deposit, or it may be absorbed. An electrode for the treatment of sinuses with this metal may be improvised from copper wire.

The Silver Ion, (diffused from the positive pole,) has been very little used. The deposit within the tissues causes little irritation and may remain permanently, dissociated into an oxide, as a permanent blemish under the influence of light.

The Ferric Ion, (diffused from the positive pole), has been tested by us in malignant growths with negative results. Its brown deposit in the skin may become painfully evident to any physician who mistakenly used a steel needle as positive pole in the epilation of superfluous hairs. In one instance known to us the deposit was extracted by using a fresh needle as negative pole, after a rather prolonged application at the same spot, an instance of cathodic depigmentation.

CHAPTER IX

LOW VOLTAGE WAVE CURRENTS
THEIR PHYSICS AND PHYSIOLOGIC ACTION

Wave Action of Electric Currents—Explanation of Wave Action on Neuron and Muscle—Importance of Shape and Duration of a Wave—Wave Frequency in Low Voltage Currents.

In the preceding parts of this work we have considered the action of the waveless galvanic current only, for effects on the body that do not need variations in its flow and that are hampered by them. These effects are chiefly chemical, vascular or drug diffusing.

Wave Action of Electric Currents.—That quality of a current so undesirable in straight galvanism and diffusion of drugs; current variations and interruptions, is important in another therapeutic field, that of artificial stimulation of function in nerves and muscles.

It was about 1844 that Prof. Emil du Bois Reymond, of Berlin, announced the law of electric stimulation of neuron and muscle that remains today the true interpretation of neuromuscular electric stimulation and should be called the *wave action*. This law is as follows, in simple language.

A neuron or muscle is not stimulated by a weak current of electrons, but only by waves in this current, on either their ascending or descending slopes; the stimulation being proportional to the power of the wave interpreted as follows: the weaker the wave in milliamperage the higher must the voltage be to produce a given stimulation; conversely, the stronger the wave in milliamperage the weaker may the voltage be. Moreover, with a given milliamperage and voltage in a wave, the quicker the voltage rises the greater the stimulation.

Scanned closely, these facts are exact statements of the powers of all waves of substances or of energies that move in waves. Standing in the surf at the seashore, we all know that a small wave with a high crest will hit a harder blow than the same quantity or volume of water with a low crest; and, also, that a low wave must be a broad one to take us off our feet. Finally, we know that a wave with a given height and bulk will hit us harder if it has a steep front.

Explanation of Wave Action on Neuron and Muscle.— If, in a state of quiescence, the molecules of a neuron or muscle, the seat of the continuous, minute electric changes incident to metabolism and function, are suddenly thrown into another chemical formation by a foreign electric current with a flood crest, an immediate rearrangement of the ions of the part is precipitated, more or less violent and powerful in proportion to the volume of the wave and the height and sharpness of its crest.

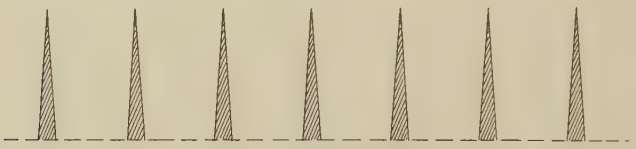
It is important to note that the effect of this wave on these tissues differs at the negative and positive poles. The neuron response is always greatest at the negative pole, in both health and disease. The muscle response is also greatest at the negative pole in health, but, when the muscle is cut off from its trophic center by disease or injury, the response becomes greatest at the positive pole of a galvanic current and remains so during the degeneration that follows severing its trophic supply and a part of the period of its re-generation. This latter response is therefore of diagnostic value.

The question arises: What is the explanation of this difference of polar wave action? Is it due to the wave of electrons being always from the negative pole, the action at positive closure being a weaker return wave crest of negative electrons into a void, as water fills a hole in its level; or is it due to its chemical nature at each pole, the negative wave being strongest in health because its ions are more stimulating to healthy neuron and muscle than the positive ions, and that positive ions stimu-

late a degenerating muscle fiber strongest? The latter theory seems at present the more plausible, and to offer the only explanation of the muscle change.

Importance of Shape and Duration of a Wave.—A result of the principles of all waves of power mentioned in the first part of this chapter is that both the shape of a wave, as it may be recorded by a proper instrument, and its duration are important in its therapeutic use. If the *shape* is irregular, as was that of the old faradic current, (Fig. 2), it is not a single wave but a series of irregular ones. Such a wave has a maximum of pain stimulation in a mixed nerve and a minimum of motor stimulation in spite of its height, the imperfect motor response being due to interference with each other by the wavelets.

Fig. 2.



Faradic current wave

If the shape is a smooth one, without wavelets or too sharp a peak, as in the alternating current surge, (Fig. 3), we have a maximum of motor stimulation with a minimum of discomfort.

Fig. 3.

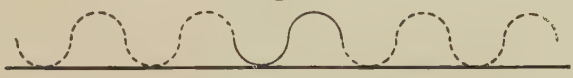
Galvanic sine wave (reversing polarity)

Waves differ in effect also due to their *duration* and *volume.* Since the faradic wave has an exceedingly slight duration, about one four-hundredth of a second, it is still used as a test in reaction of degeneration *because its brevity causes its response to be the first to disappear in nerve or muscle when the degeneration is present.*

Galvanic surging waves, that is, waves *without* reversal of polarity, produce vigorous contractions that are less painful

if the surge is smooth, (Fig. 4), and not mere makes and breaks in the current shown in Fig. 2, the amplitude of the contractions being due to their large volume and long duration. The chemical action makes them undesirable in some applications, particularly when a nickel-plated internal electrode is used as active pole, the plating being injured. Their chief use is in electrodiagnosis.

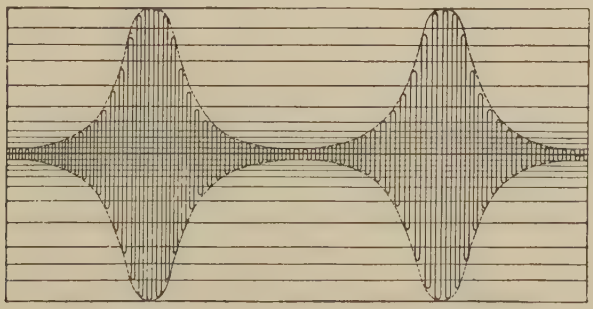
Fig. 4.



Galvanic sine wave (uni directional)

The alternating current cycle, (Fig. 3) made up of two waves succeeding each other in opposite directions, if smooth and with exactly equal crescendo and diminuendo slants, is least painful, and as its crest, duration, volume and frequency can be determined in the design of the generator and controlling device, it is the most useful type for general neuromuscular stimulation. These waves, moreover, alternate between positive and negative potentials with a *resultant total difference in polarity that is twice the height of each wave*, doubling the polar change in nerve and muscle, with consequent doubling of effect.

Fig. 5.



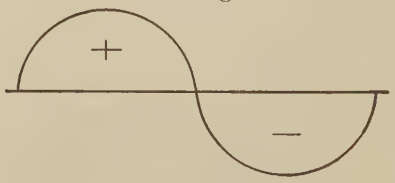
Surging Rapid Sinusoidal or Sine Wave Current

This current was re-introduced into medicine by d'Arsonval about 1890 under the name of sinusoidal, but had long been used

in a painful form of too low frequency produced by two coils in a box rotated in low gear by hand before the poles of a permanent magnet. What d'Arsonval contributed to the subject was the employment of electromagnets and a power drive, increase of the frequency of the waves to an agreeable and effective frequency, and explanation of the advantage of smooth alternating waves over the old faradic waves.

The galvanic current can also be made to flow in alternate waves of sinusoidal shape, (Fig. 6). This form of sinusoidal wave should always be distinguished in note by taking the word "galvanic." These waves produce the most powerful stimulation of nerve and muscle of all waves, due to their duration, volume and alteration. If carefully timed to least burning sensation on the skin they may not be especially painful *if the surface electrode or electrodes are sufficiently large and make perfect contact with the skin*, but no matter how perfect the technic there is some irritation of the skin that interferes with the comfort of subsequent applications. It is quite possible that the higher voltage and considerable milliamperage of the alternating surges of modern wave generators can replace them for most indications.

Fig. 6.



Galvanic Sinusoidal Current.

Wave Frequency in Low Voltage Currents.—The recent production of wave generators that not only produce waves with the desirable qualities indicated above, but permit selective variation of their amperage and surge them into tetanic stimuli applicable to different organs, has greatly extended the possibilities of wave current therapy in medicine, particularly in a sedentary population. The effect of such artificially produced exercise

of the skeletal muscles, in increased oxidation and elimination of waste, has been studied by physiologists, who have shown demonstrable effects even from slight contractions. A similar study of their effects on unstriated muscular tissue of internal organs has so far lagged, hence the need of the extensive treatment of this subject to be found in Part II of this work.

The frequency of contractions produced in a muscle by these currents is quite important.

In the first place, a muscle will not contract at all if the waves are too frequent to allow of individual stimulations, with sufficient rest between for relaxation. Yet this may happen nearly two hundred times a second, with complete contractions and periods of relaxation. Above this number per second they tend to fade, and at about 10,000 per second cease to occur. Above this frequency we have the absence of neuron and muscle stimulation characteristic of high frequency currents, though some wave effects are felt at times in imperfectly produced high frequency currents of much greater frequency, known as the faradic effects, when the trains of oscillations are spaced too far apart.

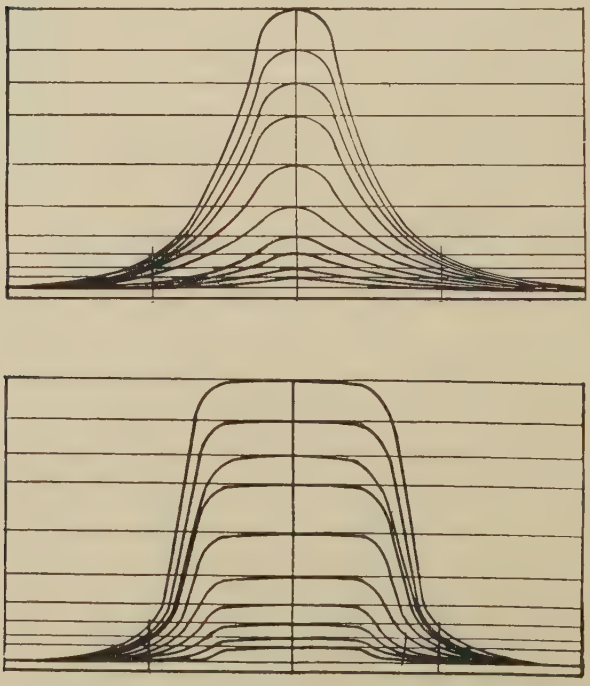
Low voltage waves may be placed in three classes in the matter of their frequency, each a distant therapeutic entity to the physician:

1. Single Waves. These are not used in actual treatment at present, though the older faradic batteries produced them by a pendulum mechanism. Save the single galvanic waves of minimal strength used in testing for reaction of degeneration, single waves are not as effective in producing ample contraction as a series of properly spaced waves, the latter producing a series of contractions that blend into a single stimulus with least pain.

2. Properly spaced sinusoidal waves, the basal waves of a surge, are themselves not as useful as when surged into super waves.

3. Surges of the last-mentioned waves, (Figs. 7 & 8,) the surges timed from about 10 per minute to about 70 per minute to correspond to the normal contraction rate of the organ, are the waves of greatest therapeutic value, in both skeletal muscles and the unstriated muscles of the internal organs. In the skeletal muscles they produce greatest stimulation with least fatigue. In unstriated muscles, the blending of many wave impulses into a surge is more likely to start a contraction in these sluggish fibers than either single waves, with the possible exception of the galvanic, or a tetanizing series without periodic remissions.

Figs. 7 and 8



CHAPTER X

ELECTRODIAGNOSIS

Scope of Electrodiagnosis—Wallerian Degeneration—Reaction of Degeneration—Faradic Test—Galvanic Test—Condenser Test.

Electrical tests for diagnostic purposes are limited to two investigations, the principal one being for *exact, scientific evidence of the present existence or recent occurence of an injury to a motor nerve or to the anterior horns of the spinal cord, or of an infectious or toxic degeneration of the same parts.*

The only other test of practical importance is one occasionally used by otologists in which a somewhat similar degeneration of the auditory nerve may be detected.

The motor nerve and muscle test is even more important than indicated above, for it establishes the differential diagnosis between the cerebral origin and the peripheral origin of a paralysis, such, for instance as that of the seventh nerve, where the other symptoms may be identical, though in the one case due only to an exposure neuritic attack in a rheumatic person and in the other to be a cerebral embolism.

This test enables the industrial surgeon to make a definite diagnosis and prognosis in injuries to peripheral nerves and the spine, and to detect malingerers.

It enables the medico-legal expert to detect and scientifically measure a peripheral nerve or cord injury and its probable date of occurence; and it enables him to assert scientifically that an alleged peripheral nerve injury presents no reactions that should be present in an injury of a definitely serious character at the time of examination, and thus may be feigned. A skilled use of the test should lead to a more scientific adjudication of the many suits in the courts for damages.

Wallerian Degeneration. — The anatomico-physiologic reason for the definite character of this test is the presence of trophic or nutritive neurons in motor nerves that convey the trophic influence or power from the secondary motor center in the cord or medulla to the nerve itself and to its end organ. An injury of the nerve sufficient to interfere with the transmission of voluntary motor impulses will also injure these trophic fibers of the nerve, arresting the transmission of trophic influence below the point of injury. As first pointed out by Waller, an English physiologist, a profound change, known as Wallerian degeneration, occurs in the part of the nerve peripheral to the point of injury. The best description of this pathologic change is to be found in a work by Prof. Wilhelm Erb a German physiologist who first discovered the change electrical responses due to it and named by him the Reaction of Degeneration, shortened for recording purposes to R D, and as this subject is of extreme importance in industrial surgery and legal medicine his description is appended:

"The first result of such a traumatic lesion is the degeneration of the peripheral portion of the nerve. Within a few (two to four) days the medullary sheath coagulates and breaks up into clumps, drops, granules, a process which spreads quite rapidly and leads to the formation of masses of granules and granular corpuscles. This is associated with softening, degeneration and destruction of the axis cylinder (neuraxon), together with marked proliferation of the nuclei in the sheath of Schwann. Gradually a large part of the products of degeneration is absorbed and the sheath of Schwann merely contains a homogeneous protoplasmic mass. This process spreads very rapidly from the site of the lesion toward the periphery into the finest ramifications of the nerves.

"These appearances are also associated with changes in the neurilemma; apart from the circumscribed traumatic neuritis at the site of the lesion, an increase in the nuclei in the sheath of Schwann occurs in the entire peripheral portion of the nerve,

together with a considerable accumulation of cellular elements in the endoneurium and perinurium; these become transformed into spindle cells and connective tissue, which increases to a marked extent, forces itself in broad between the individual bundles of nerve fibers and into the latter themselves, leading finally to cirrhosis of the nerve. How this hyperplasia of the connective tissues occurs is a question; whether from the irritation produced by the products of degeneration of the nerves or from paralysis of vasomotor and trophic fibers is still undecided.

"After a shorter or longer period, according to the form and severity of the lesion, more or less complete regeneration of the nerve occurs. The unsettled question as to the manner in which this is effected may be left to the histologists.

"Parallel with the changes in the nerves are analogous histologic changes in the muscles supplied by them. The first phenomenon noticeable is a progressive diminution in the size of the muscle fibers, which becomes distinct during the second week, and is very considerable after the lapse of a few weeks, and, in incurable cases, leads to complete disappearance of the fibers. The transverse striation becomes somewhat indistinct, but fatty or granular degeneration of the fibers is observed only exceptionally. A considerable increase in the number of the muscle nuclei, which are accumulated in masses and chains, occurs at the same time; finally a chemical change in the muscular substance develops and is manifested by the greater tendency of these muscles to the development of so-called waxy degeneration.

"Cellular infiltration and connective tissue proliferation in the interstitial connective tissue of the muscles also occur, and the terminal result is an evident cirrhosis of the muscle, whose atrophic and small fibers appear surrounded, after the lapse of a few weeks, by large, tough bands of fibrous tissue. In incurable cases the entire muscle is transformed into connective tissue, which may afterward become the seat of a deposit of fat.

"As soon as the regeneration of the nerve occurs the muscle is slowly restored to its normal condition, though this requires a

long time. Experimental and clinical investigations have proven that these degenerative changes are the main cause of R D."

The facts thus stated by this authority, who probably advanced our knowledge of the galvanic current further than any of his contemporaries.

Reaction of Degeneration.—If an abrupt current wave be made to traverse a normal motor nerve the sudden polarization, or rearrangement of the ions of its molecules will cause its muscle to contract, just as a false telegram may be sent to New York over a Philadelphia-New York wire by cutting it at Trenton and attaching a battery and sending key to the cut end of the New York part.

Carrying the analogy further, if the copper or iron wire after being cut could develop a diseased arrangement of its molecules that weakened or extinguished its ability to conduct a current, and this had a deleterious effect on the receiving apparatus at New York, we would have an exact duplication of the condition existing in a motor nerve and muscle during Wallerian degeneration.

In the nerve this degeneration shows in a R D by a mere fading out of responses to both faradic and galvanic currents in about two weeks after the injury.

In the muscle, the degeneration reactions are different and more interesting, due to the fact that the degeneration of an end organ differs in its characteristics and products from the degeneration in its conductor because of difference in constituents. The sharp wave of brief duration, the faradic, fails to produce a response almost as quickly as in the nerve. But the chemical powers of the galvanic current wave instead of showing less action causes early increase in stimulating effect, a *quantitative increase* of irritability being found for a time; in other words, a weaker current will produce the first switch, or minimal contraction than in a normal muscle.

The galvanic wave will also exhibit in RD in the muscle an *inverted formula of polar response*. Where, in a normal muscle the first twitch is found at the negative wave, (the basal ion concentration being most stimulating), in Wallerian degeneration the positive wave, with its acid concentration, produces the first twitch.

But the most characteristic feature of RD is the *qualitative change* in muscle response. Instead of a quick, vigorous twitch we will see a sluggish, wave-like contraction.

Degeneration reaction, therefore, may be summarized as follows:

In nerves, failure of both currents is complete Wallerian degeneration or lessened response in incomplete cases.

In muscles,

I. Loss of faradic response.

II. Quantitative increase in response to the galvanic wave.

III. Inversion of normal formula, the positive wave causing the first twitch.

IV. Qualitative change in galvanic response.

V. Loss of special activity at motor point, as this is the point of nerve supply, response in the latter being abolished.

Technic of Examination for RD. Faradic Test.—This test is always made first, and to a nerve point, the purpose being to ascertain if the nerve or muscle will fail to respond to a current strength capable of producing the first quiver or twitch at the corresponding motor point on the healthy side of the body. A slight difference between the two will indicate the most delicate degree of RD, for in any but the slightest injuries the faradic response is entirely absent.

With the positive pole of the faradic apparatus attached to a broad pad on a distant part of the body, a moist, half-inch

negative electrode is applied to the motor point and the current increased gradually from zero to the point where a quiver of the normal muscle is noted. The strength is noted, and the test made to the corresponding point on the affected side.

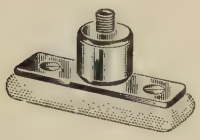
Galvanic Test.—This test is applied to the muscle, the same electrodes being used as for the faradic test, though a broader contact is made with the active electrode to the belly of the muscle instead of to its motor point. Where many examinations are made the transfer from one current to the other is conveniently made by means of a switch. Notations of the presence of qualitative change and reversal of the normal formula are made during the examination for quantitative change. (Figs. 9 and 9a)

Condenser Test.—Quantitative tests may be made either by the older method of foot-switch interruptions of the ordinary galvanic current or by the newer method introduced by Sir Lewis Jones in which accurately graded condenser discharges are sent through the muscle, a modification of the latter apparatus being made in this country. The latter have all the characteristics of the galvanic wave, with the advantages of greater accuracy of measurement in comparative and repetitive tests. When using the ordinary galvanic wave the foot-switch is preferable to one in the handle of the electrode unless the latter has a very weak spring, as the movement of switch closing will sometimes change the strength of the current by altering the pressure of the electrode on the skin.

Fig. 9.

Diagnostic electrode, for electro diagnosis (muscle testing) to determine degree of local disability.

Fig. 9a



Adjustable small top for more definite localization of defective nerve areas.

Motor points of the more important nerve exits as a guide in diagnosis and treatment. Figs. 10-11-12-13-14-15.

Fig. 10.

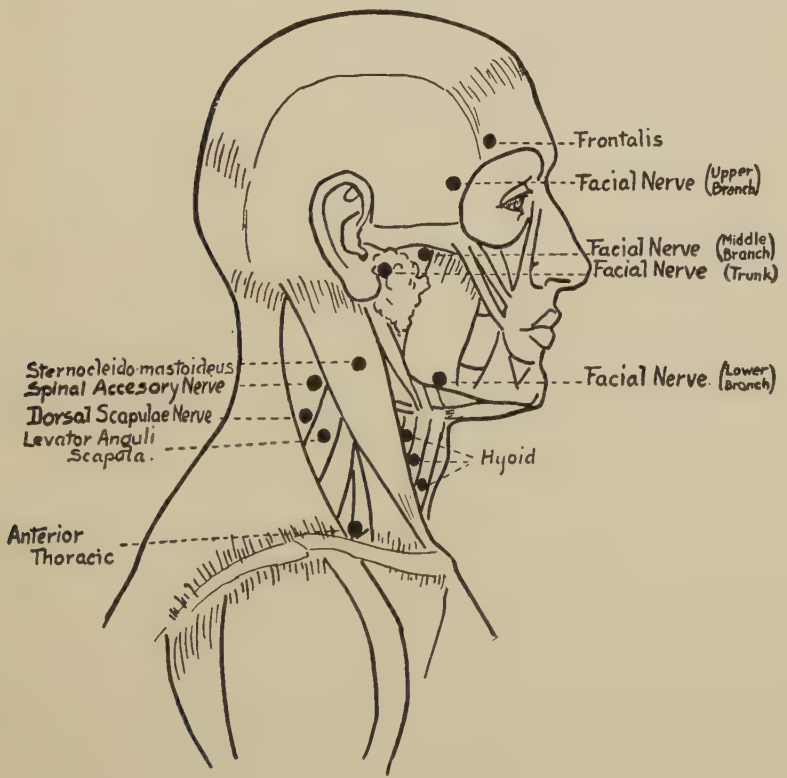


Fig. 11.

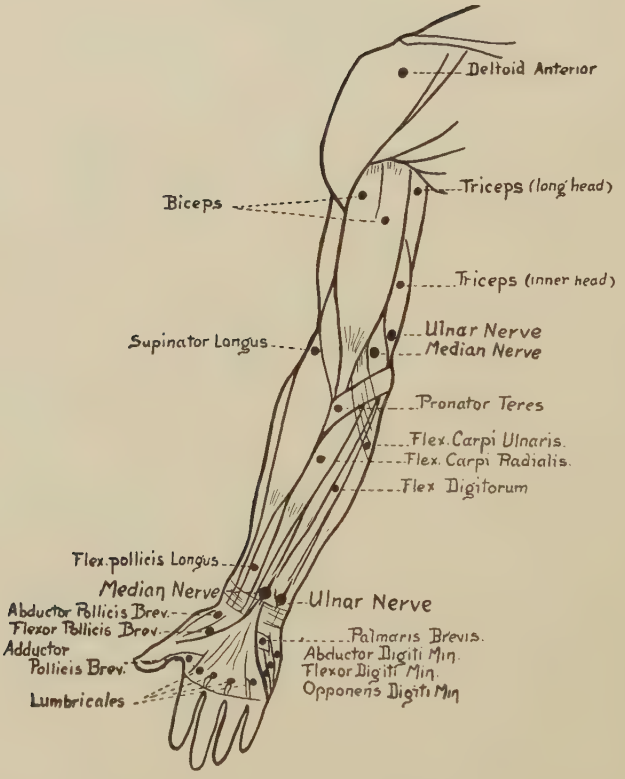

Deltoid Anterior
Biceps
Triceps (long head)
Triceps (inner head)
Supinator Longus
Ulnar Nerve
Median Nerve
Pronator Teres
Flex. Carpi Ulnaris.
Flex. Carpi Radialis.
Flex Digitorum
Flex. pollicis Longus.
Median Nerve
Ulnar Nerve
Abductor Pollicis Brev.
Flexor Pollicis Brev.
Adductor Pollicis Brev.
Palmaris Brevis.
Abductor Digiti Min.
Flexor Digiti Min.
Opponens Digiti Min.
Lumbricales

Fig. 12.

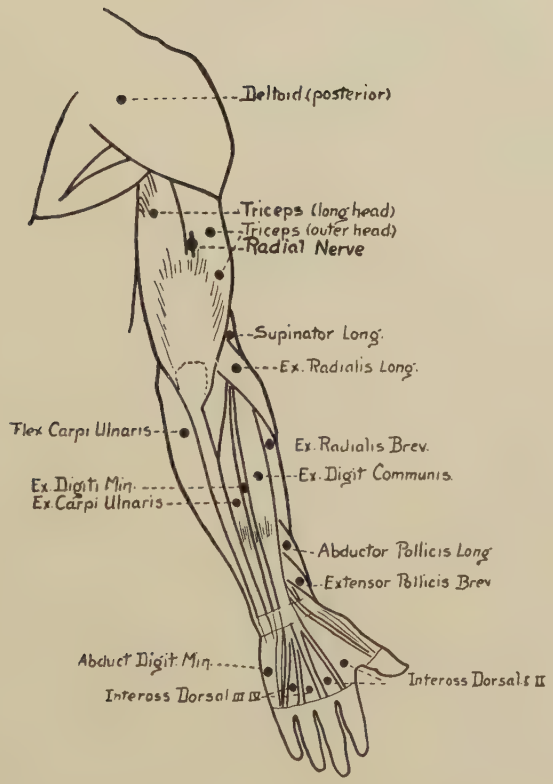

Deltoid (posterior)
Triceps (long head)
Triceps (outer head)
Radial Nerve
Supinator Long.
Ex. Radialis Long.
Flex Carpi Ulnaris
Ex. Radialis Brev.
Ex. Digiti Min.
Ex. Carpi Ulnaris
Ex. Digit Communis
Abductor Pollicis Long
Extensor Pollicis Brev
Abduct Digit Min.
Inteross Dorsal III
Inteross Dorsalis II

Fig. 13.

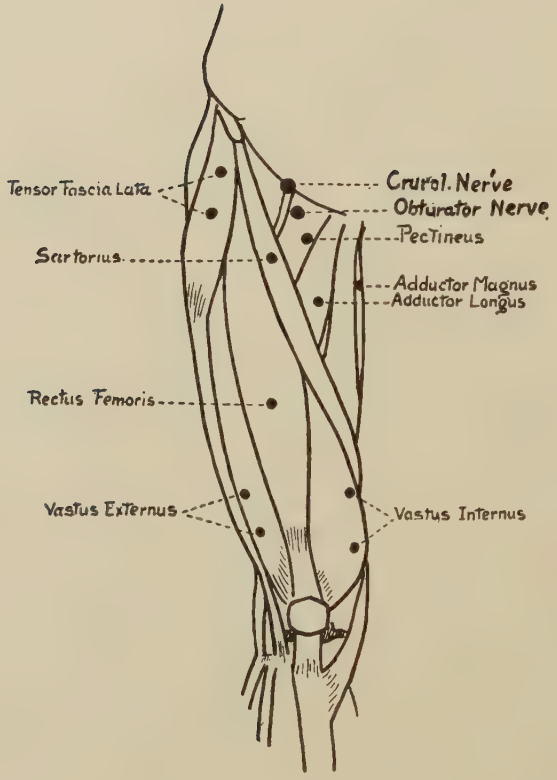

Tensor Fascia Lata
Crural. Nerve
Obturator Nerve
Pectineus
Sartorius
Adductor Magnus
Adductor Longus
Rectus Femoris
Vastus Externus
Vastus Internus

Fig. 14.

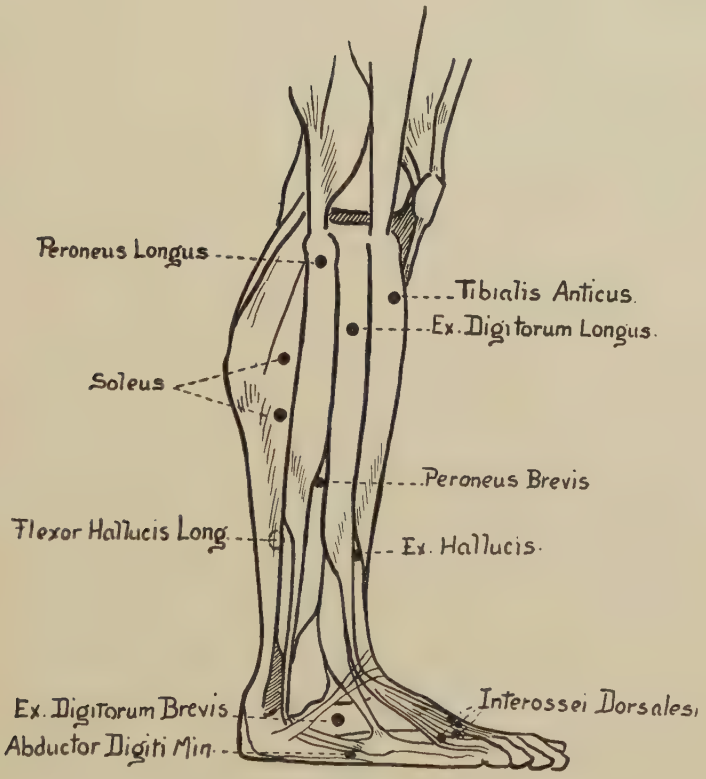
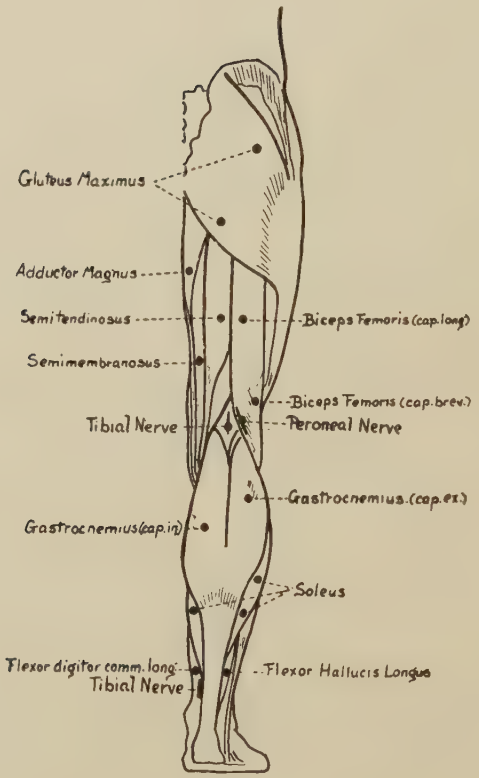

Peroneus Longus
Tibialis Anticus.
Ex. Digitorum Longus.
Soleus
Peroneus Brevis
Flexor Hallucis Long.
Ex. Hallucis.
Ex. Digitorum Brevis
Interossei Dorsales
Abductor Digiti Min.

Fig. 15.


Gluteus Maximus
Adductor Magnus
Semitendinosus
Biceps Femoris (cap. long)
Semimembranosus
Biceps Femoris (cap. brev.)
Tibial Nerve
Peroneal Nerve
Gastrocnemius (cap. ex.)
Gastrocnemius (cap. in)
Soleus
Flexor digitor comm. long
Tibial Nerve
Flexor Hallucis Longus

It would be very convenient to have a table of galvanic wave milliamperage and condenser wave microfarad strengths for each motor point in the average individual, but this is impracticable owing to variations in overlying adipose tissue, etc. The current required in the corresponding part on the normal side must be taken as a control standard for an individual. The strengths vary from ½ to 4 or 5 milliamperes in plain galvanic waves and from .01 to 2 microfarads in the muscle testing condenser.

With the plain galvanic current, the interruptions are made with the weakest currents firsts, increasing until the first twitch is noted. Stronger currents are not only more painful but splash through to the other muscles, complicating the test.

As stated before, a negative wave produces the first twitch in a normal muscle, while in RD the positive wave may equal or surpass the negative. If the switch is kept closed for a few moments with a stronger current a decided twitch may be noted at opening the circuit in RD, the positive opening contraction sometimes being the strongest in this condition.

With tests made at intervals in the progress of the disease or during recovery from the traumatism, the results recorded at each test will be helpful in prognosis and most convincing on the witness stand.

CHAPTER XI

INTERNAL APPLICATIONS OF THE GALVANIC CURRENT AND SURGICAL IONIZATION

In preceding chapters the principles of galvanic applications have been considered and the technic of the surface electrode. It remains to consider the technic of this current within body cavities and in the substance of growths. It is evident that the chemical nature of this current gives it possibilities of relief quite different and at times greater than non-chemical currents and, save for internal diathermy electrodes, possibilities of greater mischief when wrongly used.

This possibility of unnecessary trauma in both galvanic and diathermic applications within cavities in non-malignant cases is increased by the comparative lack of sensitiveness in the vagina and uterus particularly, and to a less degree in the rectum. A current that is scarcely felt when the active electrode is in the upper vagina or middle rectum will startle the patient *if the electrode is allowed to slide down to the opening of the cavity*. This shows the need of two precautions:

I. An internal galvanic application should not be gauged in dosage entirely by the patient's sensations but rather by the physician's knowledge of its effect when observed externally with the same strength, concentration and duration.

II. On account of the extreme sensitiveness of all muco-cutaneous junctions, internal electrodes should always be held steadily in position by the physician himself during short applications of a galvanic or other low volt current, or compelled to remain in position during longer ones by the handle being prevented from sliding out, in vaginal and rectual applications, by sand bags piled to limit its motion or by being held in place by some sort of electrode holder lying on the table or chair between

the patient's buttocks. The value of light shanks to internal electrodes is evident. The authors regard a holder for an internal electrode that is large enough to rest on the floor as unwieldy.

A small ionization electrode is held immobile in a cavity or sinus by being guyed in place with a strip of adhesive plaster, preventing even the smaller shocks in a waveless application.

SPECIAL APPLICATIONS

The particular diseases or illustrative cases mentioned in this chapter in describing special applications are not intended to be a comprehensive list of the possible uses of the galvanic current in medicine and surgery. They are intended to illustrate the application itself, and will doubtless suggest other possible therapeutic uses to the physician or surgeon who has mastered the technic and actions of this current.

Readers interested in the treatment of malignant growths by direct current coagulation and ionization are referred to a recent work, "Practical Electro-Therapeutics and Diathermy" (Massey, 1924), in which the latest technic of this subject is given.

CHAPTER XII

GENERAL SURGICAL APPLICATIONS OF THE GALVANIC CURRENT

Sterilization of Cysts—Accessible Tubercular Deposits and Chronic Abscess Cavities—Stimulation of their Healing by Zinc and Mercury Ions.

This use of the positive pole of the galvanic current is best described in the details of its employment in the several conditions mentioned below.

CYSTIC GOITER.—The method for the radical cure of cystic goiter to be described originated with us, and has been employed for a number of years with uniform success. The chief difficulty in its application is the uncertainty attending the diagnosis of cystic goiter in some cases, where hypertrophied parenchymal tissue is so elastic that it resembles a cyst on palpation. Uncertainties of this nature may be cleared up by aspiration with a hypodermic needle, and abandonment of the treatment if no fluid is secured.

The method is the establishment of free drainage of the cyst by a small opening in the sac through the overlying skin, converted into a temporary sinus by negative electrolysis, through which antiseptic and cauterant ions are diffused from a zinc probe amalgamated with mercury acting as positive pole. A waveless galvanic current is of course used to lessen the pain of the application. The sac walls and cavity are obliterated gradually by repeated small diffusions of the two ions at intervals of three days, these diffusions at such intervals ensuring absolutely against septic infection of the cavity during the treatment. As the cavity shrinks under the treatment a greater interval may be allowed between treatments, which are also lessened in strength until they become but slight additions to the probing to keep

the opening patulous until final healing, which may occur in seven to ten weeks, with a very small resultant scar. There has been no rise of temperature or untoward symptom of any kind in the cases treated.

Technic of Application.—With the patient lying on a large dispersing pad, a direct opening may be made by a bistoury into an undoubted cyst, under local anesthesia, the fluid evacuated and an amalgamated zinc probe of suitable size inserted into the cavity and the mercury and zinc ions diffused exactly as described for the treatment of sinuses and tuberculous cavities.

Or, in cases in which the presence of a cyst is somewhat doubtful, an aspirator needle may be made the negative pole to enlarge its opening into a sinus by previously attaching a fine wire to it for conduction of the current after the liquid has been evacuated and the needle removed from the syringe. If the aspiration shows no liquid the needle is withdrawn and the treatment abandoned, as electropuncture is of no service in non-cystic goiters. If liquid is found, a current of 5 to 15 milliamperes is turned on gradually and maintained for fifteen minutes to create a sinus, the polarity of the active electrode is then changed to positive, a fine zinc needle coated with mercury being inserted and a current of from 3 to 15 milliamperes employed for another fifteen minutes.

It is sometimes difficult to insert the positive needle until the tiny skin slough comes away, after which it is readily inserted painlessly if a drop of cocaine or novocaine solution is previously placed on the opening. The small wound is dressed with diluted zinc oxide ointment, 1 part to 10, on gauze, and the patient remains ambulant.

Surgical Tuberculosis.—By surgical tuberculosis is meant any tuberculous focus that is accessible to direct local treatment with safety to the patient.

Surgeons who interest themselves in physical therapy and who take the trouble to secure the proper apparatus for ionization and to master its simple technic, will doubtless find a broad

field for its use in a variety of tuberculous foci in open sinuses and in unopened deposits that may be reached by incision; but the data on which these paragraphs are based is limited to tuberculous glands of the neck, a number of which were reported in the work cited and to a more recent case of bone abscess of tuberculous origin.

The hypothesis on which the method is based is that the removal of a deposit of living bacilli is best undertaken in such a manner that the fresh wound made shall be sealed against their operative reimplantation, but it was later seen that even more was done by the mercury ion in re-establishing the health of the patient. Just what this is must be left to the physiologic chemist. None of these cases happened to be treated also with the ultraviolet ray, but this valuable procedure may be employed concurrently, and it is believed that the combination of the two would render special hospitals for these patients unnecessary in future.

The technique is practically the same as that described for systs and sinuses except that in these cases, the chronic abscesses and sinuses being what were known to the older surgeons as "cold abscesses" much more current may be employed at first to hasten results as little or no pain is produced. As the sinus or chronic abscess loses its "cold" characteristics and assumes those of an ordinary wound, under repeated applications, the current will have to be cut down and a drop of anesthetic solution applied to the opening some minutes before insertion of the electrode. The following case of bone tuberculosis may be cited as illustrative of the possibilities of the method in other than cervical adentis, the patient being in excellent health at present writing, eight months after cessation of treatment:

An emaciated, anemic woman of 38 years of age applied for treatment January 5, 1926. She had had tuberculous sinuses in the left leg since early girlhood, and had been operated on four years ago for tuberculosis of the left hip bone. Three sinuses had refused to heal in spite of skilled surgical attention.

Examination showed large scars at the site of operation and three open sinuses admitting probes to roughened bone, one in the upper portion of the left buttock, one at the junction of buttock and thigh, and one in the lower thigh just above the popliteal region. Treatment was begun with 15 milliamperes from zinc-mercury probes, thirty-one such applications being given during the following three months with decreasing milliamperage and frequency, when the sinuses closed, with greatly improved health, the patient resuming her occupation. Bone spicules were lifted from the openings from time to time.

Sinuses and Ulcers may be readily sterilized and stimulated into healing wounds by the zinc ion surgical technic described for cysts and surgical tuberculosis.

ZINC ION DESTRUCTION OF BENIGN TUMORS WITHIN CAVITIES

This is most useful and best illustrated by the treatment in office applications of benign growths within the nasal cavity, both hemorrhagic and non-hemorrhagic. A well-grounded suspicion of malignancy should bar this piecemeal treatment and dictate a single massive application, but benign growths of any size may be gradually destroyed by the minor method. The technic of the latter is as follows:

The active electrode, of zinc, is the size of a small knitting needle, five or six inches long, filed to a sharp point and curved slightly to reach the growth accurately. It is insulated freshly at each application by covering it thinly with fused sealing wax over a Bunsen burner except a quarter of an inch at the tip, the thin covering permitting its accurate insertion into the tumor to the depth of its uncovered part under direct illumination, after cocainization. Holding it in position after insertion, it is then guyed in place by a strip of adhesive plaster over its end attached to the face or forehead, and its light wire conductor is connected with the positive pole of the generator.

With a suitable dispersing electrode on the back, the current is turned on very gradually and without shock until 10 to 20 milliamperes is attained, which is continued for twenty minutes. The current is then turned off as slowly as it was turned on.

In hemorrhagic cases the applications may be repeated tri-weekly or oftener; in non-hemorrhagic tumors once or twice a week. Shrinkage sufficient to make the nostril patulous may be looked for after the first few applications, with eradication following later.

CHAPTER XIII

NEGATIVE POLE ELECTROLYSIS AND AS AN ASSISTANT IN DILATING STRICTURES.

Strictures of the Urethra—Oesophagus and Stenosis of Uterine Cervix.

Stricture of the Urethra.—There has been much wasted literature on the treatment of stricture by the negative pole of the galvanic current. In the first place, stricture of the male urethra is said to be not as frequent since the disuse of caustic applications. We also know that negative electrolysis is *as caustic as any alkaline ions applied otherwise.*

There is no doubt whatever that negative electrolysis will destroy cicatricial tissues if sufficiently strong and concentrated. But the final result of such vigorous treatment will not be different from that of other caustics, namely: increased stenosis after healing.

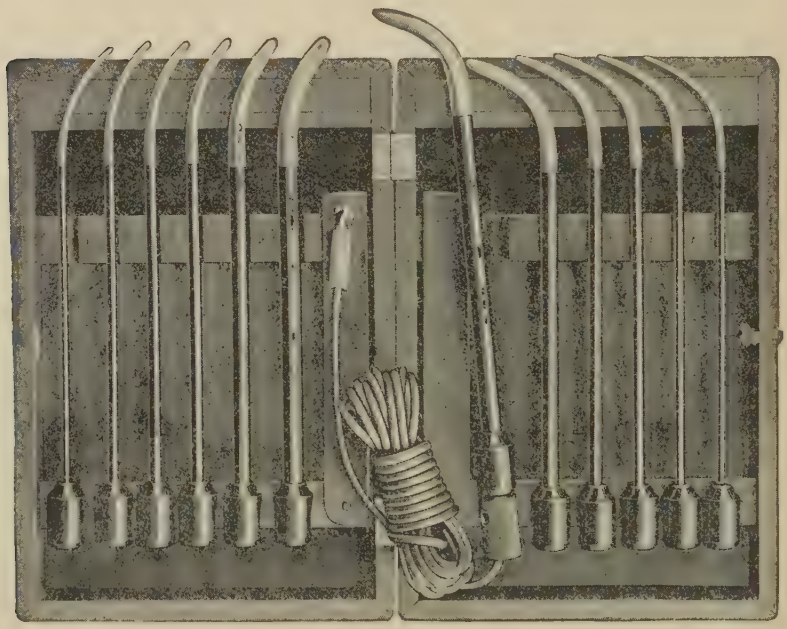
The value of negative pole water-and-alkali attraction, in the minute dose proper as an assistant to mechanical dilation, is a different question. From 1 to 5 milliamperes confined by insulation to the dilating tip will greatly assist by lubrication and have a slight sclerolytic action; and if not held immovably at one spot more than the fraction of a minute, will not cauterize.

The operation consists of first having an urethal sound used for the purpose of determining the size of the stricture and then selecting an urethal electrode one size larger than the sound that can be passed without stretching. Then place a surface electrode (4 x 5 inches) over lumbar region attached to positive pole. After proper antiseptic precautions have been taken, pass the urethal electrode until it seems to impinge in the area

to be treated and then turn on current to the amount of not over five milliamperes using very gentle pressure, but not force. If the electrode selected is not too large after two to five minutes the instrument will gradually go through the stricture. Turn the current off slowly before removing electrode to prevent an unpleasant shock. Repeat the process within seven to ten days using a larger sound and electrode and continue at intervals until the desired calibre is reached. See Fig. 16.

Stenosis of Uterine Cervix is treated by the same technic, only six or seven milliamperes may be used, a most valuable remedy for a large proportion of cases of sterility and dysmorhoea.

Fig. 16.



The same may be said of *stricture of the lachrymal duct*, but here a half milliampere will be sufficient.

In stricture of the oesophagus the current may be increased to 5 or 7, or even 10 milliamperes in accordance with the greatly increased active surface of the bulbs over which the current is distributed, giving distinct aid to the dilation.

CHAPTER XIV

THE GALVANIC CURRENT IN DERMATOLOGY

Epilation—Positive Pole Coagulation—Negative Pole Depigmentation—Negative Pole Destruction of Skin Varicosities—Port Wine Mark.

Epilation.—The negative pole is of course used for the active electrode, and the insulated kind of needle is recommended, as with this needle the electrolysis is confined to the actual hair papilla and there is no resultant scar, the surface of the skin being undisturbed by the current. Confining the electrolytic action to the deeper layer of the skin results in lessened pain also. A pair of forceps will be needed to remove the hairs as they are loosened, and this should have a soft spring for easy manipulation, the hair being lifted out rather than pulled. A magnifying glass is usually essential.

The patient should recline on a couch or tilting chair, and the dispersing pad is best laid in the patient's lap over a waterproof contact being made with the hand. This permits the current to be made and broken by lowering and raising the hand after the proper current is turned on at the controller, resulting in less painful makes and breaks than any metal switch.

The needle is passed down the follicle in the direction of the hair, avoiding piercing the walls of the follicle. With a sufficiently slender needle the bottom of the follicle is readily felt, when the current is turned on without shock until about 1 milliampere is reached. The hair root may be loosened in about twenty seconds with this current. If the forceps shows it to be still tight the current should be continued until it is loosened. The needle should not be removed unless the patient's hand is off the pad, and it should remain off until reinsertion.

The considerable pain of this little operation may be lessened by permitting a drop of cocaine solution to flow into a hair sheath after removal of the hair, this occurring easiest if it be placed in contact with the needle before it is removed. Cocaine thus mechanically inserted into the little wounds will render nearby hairs less painful under the application, and permit an increase of current strength, but it should not induce the operator to remove hairs in close juxtaposition at the same sitting as irritation and consequent blemish may result.

Such a sitting is usually continued for thirty minutes, and should not be repeated at the same site until all soreness has disappeared. A wash of witchhazel or alcoholic mixture should be applied for several hours after the treatment.

Positive Pole Coagulation.—This application is designed to obliterate a tumerous enlargement of a bloodvessel by the production of an *absorbable coagulum* and sufficient irritation for its consolidation and subsequent absorption. It is employed in the treatment of *cavernous angioma* and *hemorrhoids*, and requires that a platinum or nearly pure gold electrode be employed. For the technic of wiring and positive pole coagulation of aneurisms see Chapter X, Practical Electrotherapeutics and Diathermy (Massey.)

An absorbable coagulum in a blood tumor is desirable in avoiding suppuration or a slough, the avoidance of an open wound being further secured by the puncture being "buried," i.e. the electrolysis being confined to the interior of the tumor by carrying the insulated part into the cavity, thus protecting the external opening from the action and permitting its prompt closing. The needle is best inserted as a bistoury in tenotomy, but in a hemorrhoid directly into the tumor.

Sufficient current, of sufficient duration, should be used until the sac is hard to the touch, the strengths and durations varying according to its size. A large angioma may require as much as 40 to 50 milliamperes for fifteen minutes or longer, while a

hemorrhoid hardens in fifteen minutes with 10 to 15 milliamperes. General anesthesia, preferably with chloroform, is essential in the treatment of an angioma in a child, while a surface swabbing of some flakes of cocaine will suffice for a hemorrhoid.

D'Arsonval coagulation is largely used for hemorrhoids, but it is believed that the positive pole application has a less painful technic and is less likely to produce an open wound.

Negative Pole Depigmentation.—Freckles, pigmented moles, accidental or intentional implantations of pigment such as tattoo marks, and even powder marks in the skin, may all be successfully removed by the negative needle, the current precipitating metal pigments against the needle in alkaline froth, including the pigment base of the pigmented mole.

These applications are painful, due to the natural pain of this pole and also the considerable time and current needed to loosen the pigment. Freckles require the least current and tattoo and powder marks the most of both current and patience. The smallest sized half-curved steel surgical needle is most convenient as the point may be inserted parallel with the skin surface. It is held in a handle of light weight without current breaking mechanism, the current being turned on after insertion of the needle.

We have employed this method for the removal of a brown discoloration a square inch in size on the cheek of an eleven months old baby. The baby was anesthetized with chloroform and laid on a large, warm kaolin pad connected with the positive pole, and the active pole was the smallest size half-curved surgical needle held in a handle. This was inserted parallel with the surface immediately beneath the cuticle. When a current of about 15 milliamperes was turned on a brown froth appeared at its sides, and it was possible with this current strength concentrated on an eighth of an inch length of this fine needle to actually move it sidewise beneath the cuticle, entirely removing the color, which when wiped away by an assistant, discolored

four ounces of water. A part of the work had to be repeated some months later with a final white scar, as it was found necessary to destroy the upper layer of the pigment-producing cells also.

Negative Pole Destruction of Skin Varicosities.—In capillary varicosities of the skin of the nose the negative pole, with a very fine needle, will cause instant disappearance of each enlarged capillary vessel a few moments after the needle is inserted into it and a fraction of a milliampere turned on. The final result is excellent. The positive pole, though less painful, is more likely to cause a temporary blemish.

Port Wine Mark.—A congenital diffuse angioma of the skin is treated in the same manner, but with a multiple needle electrode that has an adjustable insulating collar to limit the perpendicular penetration of the needles, and of course much more current is used. A white scar will result from each needle action, the intervening tissue being treated at subsequent application, but these should not be made until all irritation from the previous application has disappeared. The treatment of a large "mother's marks" is therefore a prolonged one.

CHAPTER XV

GALVANIC CURRENT IN OPHTHALMOLOGY

Negative Pole Stimulation and Basal Ion Extraction—Extraction of Basal Ions in Retinitis Pigmentosa and Incipient Cataract—Sclerolysis with the Negative Pole—Iodine Diffusion with the Negative Pole—Negative Pole Electrolysis of Benign Growths —The Galvanic Current in the Nasopharynx—Drug Diffusion within the Nasal Cavity—Destruction of Benign Growths by Positive Zinc Puncture—

Negative Pole Stimulation and Basal Ion Extraction.—Medical applications of waveless galvanism are made with moist electrodes within glass cups, that fit the contour of the surface of the eye with the lids closed. The current, always a weak one of 1 to 5 milliamperes, traverses the orbital contents after passing through and between the lids. As chemical action alone is desired the current in all these applications is as waveless as possible and turned on and off without shocks.

It is evident that such an application has absolutely different effects with the two poles, the negative pole effect being usually described as stimulating the circulation and the positive as sedative. But our present understanding of polar action indicates greater possibilities for straight galvanism in eye affections,

Extraction of Basal Ions in Retinitis Pigmentosa and Incipient Cataract. It is indisputable that a negative application to the orbital contents with moist cotton in an eyecup electrode will *extract bases from the molecules of nearby tissues, precipitating them on the metal plate at the bottom of the cup,* the extraction being in direct proportion to the milliamperage and its duration. *Retinitis pigmentosa* has been reported as favorably affected by negative galvanism, doubtless due to the extraction of the bases of the deposited pigment.

Sclerolysis with the Negative Pole.—This procedure, described below, has a direct application in *corneal opacities*, good results being reported by Leduc, Alleman, Harris and others. It is applied to the cornea with a cotton swab wire electrode, the cotton being saturated with normal salt solution and applied directly to the opacity, with a current of 1 or 2 milliamperes for two to five minutes, after cocainization of the conjunctiva. The lids are kept retracted with the fingers of the left hand and the electrode is not allowed to come into contact with their edges, as these are much more sensitive than the conjunctive. The best results were in cases reported as in their early stages.

Iodine Diffusion with the Negative Pole has been employed in *ulcers of the cornea*, with a similar technic, a 1 per cent, potassium iodide solution being employed and a current of ½ to 2 milliamperes.

Negative Pole Electrolysis of Benign Growths.—*Pterygium* and *tarsal cysts* are readily destroyed by the negative needle with less tendency to the production of a slough than the positive needle or desiccation. The pterygium may require 2 milliamperes for some minutes, the fine needle being gradually moved from its apex to the base of the growth without breaking contact. It is inserted into the growth itself, parallel with the sclera. The cyst may be permanently destroyed with about 1 milliampere for a minute.

Hemorrhagic Retinitis, Incipient Optic Nerve Atrophy.—are often quckly relieved and the degenerative process retarded by the application of mild negative galvanism (1 to 3 milliamperes) frequently. The author has often seen a partial restoration of sight which continued for years where cases have seemed hopeless. **Iritis.**

The pains of Iritis as well as other congestive affections of the orbit are usually quickly relieved by the application of positive galvanism.

Conjunctivitis.—The catarrhal, and the granular form of this affection respond to zinc sulphate solution applied on a cotton covered small tipped electrode, made of platinum, gold or zinc, or a pure zinc tip properly shaped. The positive must be the active pole used. The negative surface electrode may be placed under the hand, so the patient can control the toleration of the current by more or less pressure on the electrode.

CHAPTER XVI

THE GALVANIC CURRENT IN THE NASOPHARYNX ORAL CAVITY AND EAR

Drug Diffusion within the Nasal Cavity—Destruction of Benign Growths by Positive Zinc Puncture—Granular Pharyngitis—Hypertrophy of the Turbinates—Otitis Media.

Drug Diffusion within the Nasal Cavity.—This therapeutic procedure needs further study of the older literature, as interpreted by our present knowledge of polar action and drug diffusion. Straight waveless galvanism or drug diffusion may be applied to the mucous membrane on slender, cotton covered wire loop electrodes or shepherd crook electrodes, the loop or crook preventing loss of the cotton in the cavity and imparting the qualities of a blunt, flat electrode when covered. These applications are well borne after mild cocaine swabbing. Mouth applications can be made without cocaine.

Galvanic medicinal applications to the throat, on the contrary, are badly borne owing to their stimulation of the reflexes.

Destruction of Benign Growths by Positive Zinc Puncture—This procedure, is particularly valuable in both hemorrhagic and non-hemorrhagic growths within the nasal cavities, as any desired amount of power can be applied directly into the

growth from slender electrodes that are curved by the surgeon to conform to the cavity, the electrode being thinly covered with insulation and capable of exact placement. A single application of a strength proportional to the area of the growth will often arrest the hemorrhage, and when repeated at intervals of two days to a week will cause complete disappearance of the growth in a few weeks, without a bloody operation and without subsequent recurrence of the growth if the base has been completely destroyed.

In *Granular Pharyngitis* the application of zinc with properly shaped electrodes by the metallic electrolysis method is very efficient; likewise a similar procedure in cases of *Hypertrophy of the Turbinates*, or in the latter case a 2 per cent. solution of zinc sulphate using a platinum, gold or zinc tipped applicator electrode covered with absorbent cotton, of course. The positive pole will be the active one. The amount of current used will be to the point of easy toleration, usually one to three or three to five minutes. If the local application of cocaine or butyn be made any possible burning sensation can be obviated.

In *Otitis Media* a two per cent. solution of zinc application is almost a specific. The author has repeatedly observed the disappearance of the purulent discharge after a few treatments. But electrolysis of urethral stricture, if properly carried out by having respect for the delicate tissue involved combined with careful technic, can be made a successful and satisfactory procedure.

CHAPTER XVII

GALVANISM IN GYNECOLOGY

Aseptic and Other Precautions—Wave Stimulation of Muscle and Neuron—Positive Pole Applications to Vaginal Cervix—Insertion of Intrauterine Electrodes—Negative Pole Intrauterine Applications—Positive Pole Intrauterine Applications—Positive Pole Surgical Ionization of External Growths—Uterine Fibroids—Uterine Displacements—Endocervicitis and Erosion of the Cervix.

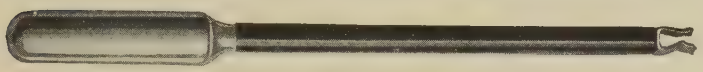
Aseptic and other Precautions.—The first precaution is proper cleanliness of the hands and instruments, for though the extreme asepsis of cutting operations is not needed, the hands and instruments should be clean and germ free.

The second precaution is that the office practitioner without special training in gynecology should secure a confirmation of his diagnosis in the more serious cases whenever possible, so far as a diagnosis can be made by vision or the bimanual touch. Many minor conditions of relative distress can fortunately be relieved without absolute local diagnosis by vagino-abdominal wave currents, for many patients have been referred to surgeons for uterine trouble, and some operated on, for sigmoidal stasis without the presence of uterine disease. *But no intrauterine applications should be made unless the presence of tubal inflammatory trouble, a latent pelvic peritonitis, or pregnancy, have been excluded.*

Wave Stimulation of Muscle and Neuron.—This is a most valuable resource to the office practitioner with a feminine clientele. Alternating surges, under thirty per minute, are usually indicated. With a sufficiently large moist surface electrode on the abdomen and a cylindrical vaginal electrode, (Fig. 18) passed back of the cervix, a half-hour treatment given tri-weekly will tone up the muscles of married women, stimulate the pelvic

circulation, including that of the ovary, and at the same time help to overcome the sigmoidal stasis so common with them. No routine procedure could be more valuable, with or without some preceding diathermy.

Figure 18



Vaginal Electrode for Alternating Current

Various relaxations, displacements and other mechanical faults should not be corrected by taking a tuck in the relaxed part until a more scientific method has been tried. One would not take a tuck in a suspender that had lost its elasticity if its relaxed rubber web could have this quality restored; and this is what can be done at times by wave current therapy in the relaxed muscles of women who are not aged.

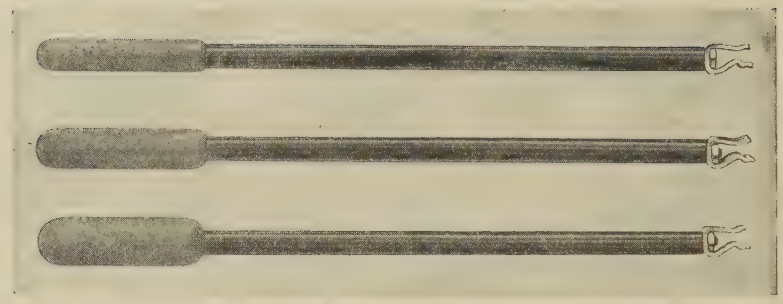
Nickel-plated electrodes are suitable for alternating current only. A carbon ball electrode, (Fig. 19), which should be covered with cotton and moistened, is necessary when galvanic sinusoidal waves are used. The wet cotton may be lightly soaped for easy insertion when a speculum is not used. We use a carbon ball vaginal electrode, (Figs. 20-21-22) for galvanic waves frequently.

Figure 19

Carbon Tip Galvanic Electrode.

The design usually employed

Figures 20, 21 and 22.



Other forms of Carbon Electrodes used for Rectal or Vaginal work.

Positive Pole Applications to Vaginal Cervix are indicated in erosions of the cervix. An active electrode of copper or zinc, (Fig. 23), with all surfaces insulated except that in contact with the erosion is most convenient. These cases generally require intrauterine treatment to reach the source of the irritating discharge.

Figure 23

Copper Tip Electrode

Insertion of Intrauterine Electrodes.—We have used the method of Apostoli in insertion of intrauterine electrodes or sounds for years, with a minimum of discomfort to the patient and avoidance of tenaculum wounds in the cervix. This method is superior to that requiring a speculum and tenaculum for the reason also that the educated touch within the vagina during the insertion, coupled with that of the external hand on the abdomen, give a better knowledge to the physician of the position of the body of the uterus and the direction of the axis of the

uterine cavity—a knowledge that is often lost by the distortion of the speculum, even after the position had been ascertained by a previous examination. The technic, which permits of conforming the electrode to the cavity rather than the cavity to the electrode, is as follows, (Fig. 24):

Figure 24

Intrauterine Electrodes

Negative Pole Intrauterine Applications.—These applications are made for *atersia of the uterine canal*, 5 to 10 milliamperes for five minutes, *infantile uterus*, the same strength; *subinvolution*, 20 to 25 milliamperes for five minutes, followed by fifteen minutes of alternating current surges with the same electrodes; *prolapse*, the same as for subinvolution.

Intrauterine applications should not be made when inflammatory conditions exist in the appendages, nor should they be repeated oftener than every five to seven days, except, in the case of the positive pole, they may be made oftener for the urgent control of hemorrhage in a bleeding fibroid.

It should be unnecessary to state that the electrode is first sterilized. Ascertain the curve of the cavity by a preliminary bimanual examination and select an electrode to fit the curve. With the left finger locating the os, lift the cervix slightly by the finger under its posterior lip and pass the tip of the electrode along the palmar surface of this (left) forefinger until it engages the os, when the handle is gently depressed curving the tip forward in the line of the cavity, in which it usually glides easily, though ther is sometimes difficulty in passing the internal os. If this is not surmountable by patient effort *without force*, remove the instrument and try a larger one, as the tip may have been caught on a fold of the mucosa, or, finally, a smaller one. The instrument should be supported at its handle during treatment.

Such a method has the apparent disadvantage of soiling the instrument with the vaginal discharge, but over forty years experience shows this to be illusory.

POSITIVE POLE INTRAUTERINE APPLICATIONS.—This pole is indicated when the discharge from the uterine canal is persistently purulent, a copper intrauterine electrode amalgamated with mercury being preferable, with a current of 10 to 15 milliamperes for ten minutes, according to the case. In *metrorrhagia* from any cause, (save hanging polyps, which should be twisted off with forceps) the positive pole may be relied on to control hemorrhage almost at once, with currents from 10 to 20 milliamperes, the latter strength only with a large tipped instrument in the capacious cavity of a bleeding fibroid. With the larger dosage the largest instrument capable of insertion without dilation should be used, and at times the duration should be applied to more than one section of the cavity at the application, with a total duration of not longer than fifteen minutes.

Positive Pole Surgical Ionization of External Growths.—An example of the use of this method in gynecology is the destruction of *caruncle of the urethra*, in which its use is somewhat less painful than desiccation.

As these growths are extremely painful and often extend an inch or more up one side of the urethra, the method of local anesthesia is important, insertion of the hypodermic needle being unbearable. This may be avoided by placing cocaine flakes on the caruncle ten minutes before insertion of the hypodermic needle, and adding more flakes during the ionization, the cocaine being dissolved by the moisture of the part.

With a large dispersing electrode on a distant skin surface and connected with the negative pole, three fine zinc needles are cut from thin zinc plate, each about two inches long, filed to a sharp point, and connected to the positive pole with fine wires.

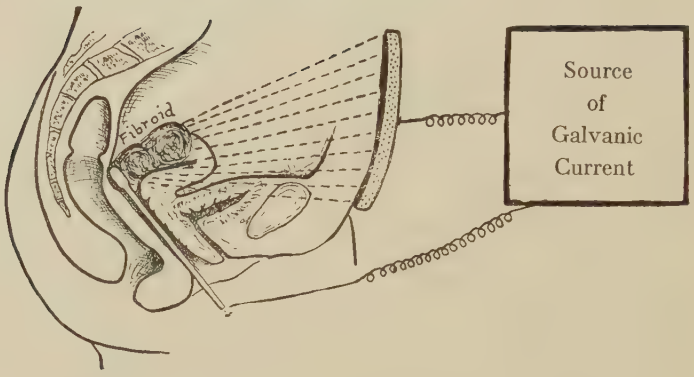
These are passed into the growth and a current of 3 to 5 milliamperes turned on without shock. As the ionization proceeds more current is turned on, until finally the whole growth turns white. An ointment dressing is used during the separation of the small slough.

Uterine Fibroids.—Ever since the famous gynaecologist, Dr. Georges Apostoli of Paris, appeared before the British Medical Association in 1887 in defense of the treatment of fibroids and other non-purulent and non-cystic conditions of uterine adenexa there has been much controversy on the subject. The subperitoneal and submucus variety, also the rapidly growing forms and those that have attained a size to cause sufficient pressure on adjacent viscera are recognized as being strictly surgical. All of the above varieties and conditions would probably fail to respond to galvanic treatment but more likely harm would follow the procedure, perhaps not so much by application but because valuable time would be wasted while something radical should be done.

However, there is a large proportion of cases of the interstitial variety when the only disturbance is either bladder or rectal pressure, or both, that are amenable to quick relief by positive galvanism applied in the vagina.

The technic consists of having a large, moist, abdominal, well saturated electrode made of a material that will diminish skin resistance to the greatest degree and a carbon ball vaginal electrode well covered with absorbent cotton or gauze and so placed in contact that the current will pass through its greatest diameter using twenty to thirty milliamperes for fifteen to twenty minutes. A longer seance might cause pain due to the contractile action of the current. A copper tipped vaginal electrode should not be used as it is not the local effect we desire but the interpolar. See Fig. 25.

Figure 25



Assuming the case to be one favorable for this treatment, in a short time and sometimes after one application as outlined the patient expresses herself as having a relief of pressure and pain, if pain had been present.

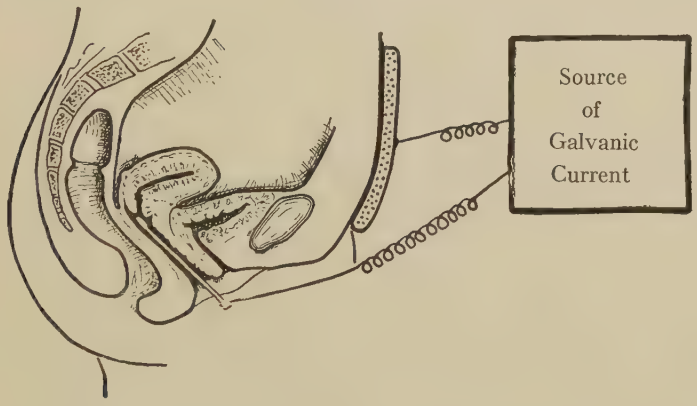
Two treatments should be given weekly at first, gradually extending time between seances as the case will allow. The fibroid will not disappear as with surgery when the patients sometimes will, but from one-third to one-half diminution is frequently noticed and she becomes symptomatically cured. What more can a reasonable woman want or expect with the alternative of facing a possible serious operation? The patient must be made to understand that total elimination is not to be expected lest someone antagonistic to the method injects his opinion and causes her to relinquish further treatment.

Uterine Displacements.—The positive pole with carbon tipped electrode is the method usually required where the condition is one where relaxation of the uterine supports of the vaginal wall is the impairment to be restored. It is the local astringent tonic effect, combined with the inter-polar action that produces the result. See Fig. 26.

If however, there are local vaginal adhesions where direct application can be made the carbon tipped electrode (covered) should be used with the negative pole where local ionization would be indicated. A thorough knowledge of the local action of the pole must be the guide to the requirements of the procedure.

Endocervitis and Erosion of the Cervix.—What has been said on surgical ionization will apply to this class of cases, but one must ever keep in mind that curettment and essential surgery must often go hand in hand in this part of the human anatomy.

Figure 26



Vaginal as well a Rectal copper tip electrodes are used with the positive pole for local astrigent effect only. See Fig. 23.

Care must be used in the application of copper or any soluble metal because of tendency to adhere to the mucus surface and if forcibly extracted may cause a denuding of the membrane. When it is removed this is easily obviated by turning off the current and changing to Negative pole for Internal electrode for about two minutes which will release it, use but little current in

this procedure as a reversal of the Galvanic current will often cause a painful contraction. The surface electrode for Vaginal application may be on abdomen or back or with a bifucated cord or both all dependent upon the part of the Vagina when special treatment is desired.

In relax vaginal conditions a bipolar electrode to be used with the Faradic or rapidly alternating Sinusoidal Current. Never with the Galvanic Current. See Fig. 27.

Figure 27

Bi-polar Vaginal Electrode

Fig. 27 Shows bi-polar vaginal electrode, where the vaginal walls have become relaxed and local conditions as might be indicated, for the use of alternating or faradic current only.

CHAPTER XVIII

THE GALVANIC CURRENT IN UROLOGY AND PROCTOLOGY

Positive Pole Sterilization and Stimulation of Ulcers—Positive Pole Coagulation of Hermorrhoids.

Positive Pole Sterilization and Stimulation of Ulcers.—This has been employed successfully in *fissure in ano*. A blunt zinc-mercury electrode is pressed against the fissure, previously cocainized, and a current of 2 or 3 milliamperes applied for five minutes, followed by an ointment dressing. The treatment should be repeated in three weeks if the painful condition persists.

Positive Pole Coagulation of Hemorrhoids.—The technic of this procedure is similar to that in cavernous angioma, except that the puncture is made into the hemorrhoid direct and that but 7 to 10 milliamperes are used. A platinum-iridium needle is employed, insulated with hard rubber or fused sealing wax up to one-eighth inch of its point. This is inserted, after cocaine ionization, with the insulation carried into the cavity of the hemorrhoid, thus making a buried puncture. The electrode may be placed through the speculum, the latter being then withdrawn while the electrode is held in position; and when a strip of hard rubber is passed up the rectum behind the spot under treatment to protect the opposite rectal wall, the latter may be carried out with all instruments withdrawn except the electrode and rubber strip without stray current effects. The current strength mentioned will cause coagulation of the hemorrhoid in fifteen to twenty minutes, which will be organized and absorbed without a slough being formed.

PART II

LOW VOLTAGE ALTERNATING CURRENT

CHAPTER I

TECHNIQUE—LOW VOLTAGE

Alternating Current—Sine Wave Currents—Rhythm—Technique of Treatments.

The alternating current is one which periodically flows in opposite directions, and in each direction for the same length of time, and whose variations in strength when flowing in either direction take place in the same manner and are equal in amount.

When the current has passed from zero to a maximum value in the one direction, and through zero to an equal distance in opposite direction and returns to zero, it is said to have completed a cycle. Fig. 3. The number of cycles gone through in one second is termed the "frequency of the current."

The alternating current has been efficient in therapeutics chiefly because of its indispensable use in the production of X-ray and high frequency currents. The localization of heat all the way from fine desiccation to extensive diathermy procedure, is in a class by itself. The localization of heat enters into relief and curative action of such a vast number of painful symptoms and diseased conditions that indications for its use are almost limitless.

But there are other uses of alternating currents, when the waves are of low voltage, low frequency and sine shape, that are considered in this work, by which full physiologic stimulation of internal hollow organs as well as external muscular fibre may be produced. It is by this means that intestinal stasis and functionally impaired muscular areas of various parts of the body, can be definitely acted upon without the production of heat or chemical action.

The combination of heat and deep molecular massage often is of greater benefit in the majority of chronic cases than either one alone.

SINE WAVE CURRENTS

In 1883, Dr. Kellogg devised a mechanism consisting of coils and magnets which produced a current of a much smoother quality and apparently of more value in the treatment of impaired muscles than the Faradic current. In 1886, he presented a paper before the American Medical Association describing the apparatus and claiming distinct advantages over his earlier discovery, which was really an alternating form of current produced by magnetic induction.

In 1892, D'Arsonval of Paris produced an apparatus consisting of more coils and more magnets to which he gave the name "sinusoidal" current. It was later discovered that it was practically the same idea as that originated by Kellogg, only with the greater number of coils and magnets. The effect was the same, only the current seemed to have a smoother quality because of the greater number of impulses produced. Manufacturers of medical apparatus, realizing the importance of the newer method, reproduced mechanisms under different trade names, producing a sinusoidal current.

More recent products on the same principle have been devised, and at present the alternating sinusoidal current, and the direct sinusoidal current, have become standardized and better understood. The rapidly alternating sine wave current, by increasing the usual sixty cycles per second to one hundred and eighty cycles, produces a blended tetanic contraction with less painful effects.

The galvanic sinusoidal, on the other hand, is a reversal of the polarity and, when made to produce muscular contractions sufficiently slow to harmonize with physiological action, the resistance of the skin and consequent burning sensation prevents

toleration and renders it impractical. A uni-directional sine wave does not reverse its polarity, and is of practical value because the regularity and usefulness of the polar effect is not destroyed.

It is vastly important that the duration and frequency of the wave should be in keeping with physiological functions which can be easily determined, and the strength of current and length of time during application is also another essential, lest failure to simulate normal nutrition of the part causes undue stimulation, which might defeat the object to be accomplished. This applies perhaps more to the direct current, as the element of heat is there involved and must be considered as well. The alternating current, unless used with the proper recognition of the number of cycles per second harmonious with cellular activity, may also fail to accomplish results because of local irritation and resistance induced. It is unnecessary to state that the definiteness of the measured wave currents must appeal to any physician who desires to get away from the empiricism, which is a too common practice.

The wave current principle, from whatever source the origin may be, is being recognized as a wonderful help in physical therapeutics, and the prime object of sine current is to enhance the value of the different electric currents with which we have all been familiar; but unless normal muscle action of the part is recognized and respected and treatment applied accordingly, the results are likely to be disappointing. With the present literature on the subject, combined with the improved mechanism to carry out the theory, there should be no excuse in selecting the proper method to fit the case at hand.

An apparatus has recently been devised whereby the surging currents of wave generators can be so utilized with a diathermy apparatus that the combined action of the two can be used. This device is constructed so as to permit the application of the diathermy and the sinusoidal alternating current simultaneously. The advantage of this is that a collective wave current impulse can thus be utilized.

RHYTHM

There has been much empiricism in medicine in general, and likewise in our subject, physical therapeutics.

As physicians, we are interested only in what applies to the human body, in the maintenance of health and the prolongation of life.

When a physician is consulted, the patient usually has a pain or some prominent symptom that has stimulated him to call for help. It is safe to assume the patient has either the result of traumatism or infection. It is usually easy to determine the injury, but the source of infection may be near or remote from the affected area, and its discovery is the one determining factor to decide the course of procedure for relief or cure.

Following injury or infection, after the acute inflammation has subsided and necessary surgery has been done, along with other remedial measures, nature makes an attempt at repair, and if on account of age, low resistance, or other debilitating causes, she makes little or no progress, then it is the physician's place to take a hand, and attempt to assist restoration of function.

With a proper understanding of the physical and electrical methods now at hand, one has only to select the method that might apply. To combat infection and assist cell activity, we must use either heat, mechanical, or chemical action, or by a combination. Outside of local and constitutional effects of the various forms of light application and the Xray, it is the heat and mechanical action that in the majority of cases we must depend upon.

Any attempt at restoration of muscle and nerve function toward normal activity must be dealt with in reference to the physiological action of that part under treatment. Otherwise a discordant rhythm will be the result, and harm might ensue.

The above remarks bring us back to normal rhythm of the different tissues, and should make us willing to re-study our physiology when using physical therapeutics, as a better guide for obtaining good results in treatment than the literature that usually accompanies physician's apparatus to instruct him how to "cure" his patients. Too often this is his only source of information.

Whatever applies in nature to growth, maintenance, and perpetuity, necessarily applies to that vital principle we call cell activity, which is the essential element of prolonging human existence. Whatever similarity there may be in vegetation and human life, there is one principle that is recognized, and accepted; that there is a certain coordination of activity which is known as rhythm.

Anatomy is the knowledge of the structure of the human body, and is not changeable. Physiology is the sum of the activities of the various functions of the body, and is constantly changing, and that change, which we recognize as impairment of function, is a tendency toward disease, and we meet it in all stages; consequently, our knowledge of what we would do, if we could, must be guided by normal physiological semblance. Advanced age, constitutional disease, and diminished resistance from various causes, are always important considerations when therapeutic results are looked for.

If the body is to work efficiently and to develop its physical powers to their full extent, it is absolutely essential that the movements of the muscles on the one hand, and the activities of the circulatory and respiratory systems on the other hand, should be coordinated and integrated into an harmonious whole. Perfect coordination brings about the maximum of work, with the minimum of effort. Incomplete coordination, on the contrary, inevitably spells inefficiency.

An exaggerated response to stimulation on the part of the respiratory, circulatory, or muscular systems, either locally or as

a whole, involves a useless expenditure of energy. On the other hand, a deficient response likewise impairs the efficiency of the mechanism, and renders necessary function ineffectual or totally inert.

It is in keeping with this thought that wave current therapeutics to synchronize muscle action were evolved, and clinical experience has shown the usefulness of the procedure. The definiteness of the principle is shown by the accuracy with which it can be demonstrated, and it is generally adopted by those whose experience and knowledge have taught them the importance of recognizing and respecting normal physiological action.

To use the galvanic current intelligently one must understand the physics of this current, so one should have a knowledge of the underlying principles that keep the mechanism of the human body at the zenith of function if we wish to aid in this effort.

TECHNIQUE OF TREATMENT

As in drug therapeutics, any medicine sufficiently powerful to affect body tissue if used too strongly or too long is as likely to do harm as to be beneficial.

While each case should be treated according to special indication, there are some general rules that might apply if the work is going to be done in a definite manner.

Although the nervous system initiates and controls every movement of the body, the energy required for carrying out the physical work is developed in the muscles themselves, and their power to transform potential into kinetic energy, which appears as exercise or heat, and to renew their store of energy is the essential of muscular exercise.

Physicians naturally desire to produce quick results, and, if in their enthusiasm, a partially paralyzed muscle is exercised to

the point of fatigue, the effect is debilitating instead of invigorating, while a shorter and less vigorous application might have been effective. For instance, in many cases of constipation, where the subject has thin abdominal walls with poor expulsive power, the alternating surging sine wave is recognized because of its ability to penetrate deeply, with pleasing toleration. The patient and the doctor feel that invigoration of the part is needed, and the temptation to make the contractions powerful and sometimes prolonged often causes a feeling of profound weariness and frequently unnecessary local soreness.

If specific technique were printed, giving exact location of electrodes, frequency of treatment, and length of seances, any information thus obtained, regardless of any real knowledge of the reason why, is bound to be more or less superficial.

The busy physician too often turns the entire physical therapy over to his assistant, who may or may not have been properly instructed. The object of this book, therefore, has been to instil in the mind of the reader the principles involved, explaining the reason WHY, which if understood, would simplify HOW and permit intelligent application to diseased parts.

In other words, the successful operator with physical apparatus should determine definitely just what he hopes or expects to accomplish, along with the knowledge of the limitations of the method, being careful not to overstimulate, thereby exhausting and inhibiting what is expected to be accomplished. On the other hand, he should not allow timidity to prevent sufficient response to the method used to insure results.

The same principle applies to the treatment of locomotor ataxia, infantile paralysis, paralysis following cerebral hemorrhage or traumatism.

Surface electrodes, when used for the purpose of invigorating the lower bowel where the alternating current with surging effect is to be produced, should be of a size sufficiently large to so

lessen its skin sensations on the abdomen that the patient may feel the contraction beneath the electrode within the colon.

It is sometimes advisable to use two electrodes connected one in front and one back, which serves the purpose of one electrode but diminishes skin irritation and allows more current to be used.

Avoid giving any form of electrical treatment in the vagina or rectum without being absolutely sure that the outside portion is held firmly by some means, not only confining the treatment where it is intended, but to avoid accidents, as it is well known that where the skin and mucous membrane meet, there is an increase in susceptibility to all forms of electricity.

The author's internal electrode support, see Fig. 28, seems to answer this purpose of holding the internal electrode in place, as it is not only effectual, but any slight movement on the part of the patient will do no harm, or run the risk of breaking a glass electrode where high frequency is being used.

Forms of electrode supports fastened to the operating table or supported by a stand on the floor have been found impracticable.

Fig. 28

Fig. 29

This is brought to your attention so that it may refresh your memory on what anatomists consider the normal position of the Viscera, and as everything in the world is measured by comparision the visualization of Fig. 29 will help better to understand those which are to follow. The radiographs here illustrated are not drawn from the author's imagination, but from his own files.

Fig. 30.

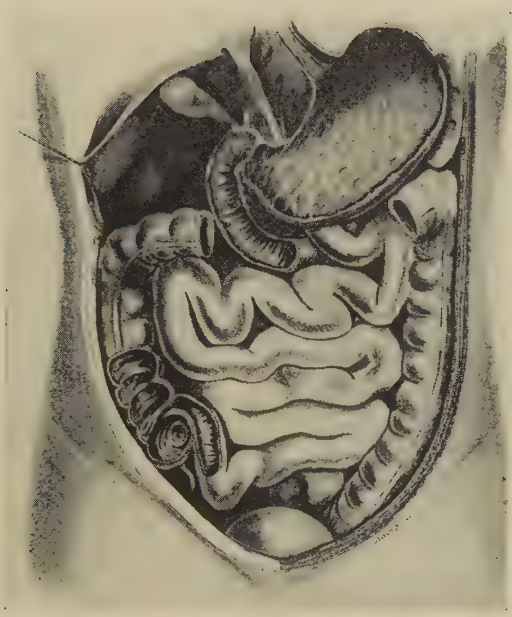


Fig. 30 shows the Normal Viscera, with the liver and Gall Bladder retracted, exposing open sections of the Stomach, Duodenum, and Caecum, and incidentally gives a clearer conception of the position and function of the Ileocecal Valve; also calling attention to the fact that the calibre and structure of the colon are the same throughout, which is all-important in interpreting X-rays of the colon.

CHAPTER II

THE INTESTINAL INFECTIONS

Faulty Intestinal Elimination—Examination without X-ray—Obstipation—Caecum Infection—Colitis—Ilealstasis—Sigmoid Toxaemia—Gall Bladder Infection—Colonic Flushing and Intestinal Irrigation.

FAULTY INTESTINAL ELIMINATION

How few persons, even medical men, give a second thought to the process of intestinal mechanism as applied to the transmission of nourishment through the body!

It is a very simple matter to make an off-hand diagnosis that one has indigestion, autointoxication, a gall bladder infection, intestinal indigestion or the more common term applying to perhaps all of these, i.e., constipation.

Any of the above general symptoms should in no way be a guide for treatment of the condition, as the diagnosis is too often made on the patient's statement regarding his or her affected area.

The more mechanical a surgeon is, combined with his other necessary qualifications, the more successful will be his results, as unexpected conditions are constantly met with that do not appear on the surface, where ingenuity, and not book knowledge, becomes the most important element of success.

To illustrate: From the time one's food enters the mouth until it leaves the body, the passage of the nutriment through the thirty-five feet of digestive tract is practically beyond the control of the individual. Nature has endowed us with a passage protected by firm and soft elastic tissue, and in state of health all corners are rounded to diminish friction and prevent delay

beyond the normal time of exit. If, however, due to wrong living, which is a broad term and may apply to everything from a faulty and unbalanced diet to improper wearing apparel, the stomach becomes repeatedly over-distended and prolapsed, the colon, as a consequence, is caused to bend at the transverse portion. The hepatic and splenic flexures become angulated to such a degree that the normal transmission process, known as peristalsis, is interfered with, and a delay of bowel contents is the result. —Fig. 33.

Likewise, a similar condition of distortion, distention, and impaction may occur in the pelvic colon, generally spoken of as the sigmoid. The condition as outlined produces what is usually described as intestinal stasis. It is not enough as a guide for treatment to make a diagnosis of gastroptosis, enteroptosis, or intestinal atony. As one grows older, or has less resistance, regardless of age, degenerative changes more easily take place at the angles described, due to a combination of local infection and diminished blood supply.—Fig. 41.

X-ray examination of the digestive tract by bismuth or barium meal is absolutely essential to determine the condition of the stomach, duodenum, and ilium, as regards ulcer, malignancy, obstructions from other causes, and the rate of movement of bowel contents.

Occasionally a twenty-four hour series of exposures will show the shape of the colon. A barium enema with the properly prepared bowel, in the hands of a good operator, will usually reveal the truth of the condition of the colon, which in the author's opinion, is more essential. It is also certain to determine the condition of the ileocecal valve, which, if incompetent, would show the barium having passed through into the ilium. This could not be determined by an X-ray by mouth as it might leave a small amount of the barium which did not enter into the caecum.

The rate of the barium meal throughout the entire digestive canal is of interest, and it is not intended to convey the idea that one should not do a sufficient amount of X-ray work to enable him to get at the truth as to where the foci of infection exists.

As it is intended that this book shall be practical, we must take into consideration the fact that many patients are financially unable to pay for an extended examination. Often an X-ray of the colon alone, by enema, is sufficient to make a diagnosis.

A radiograph of the stomach, regardless of its malposition, would be of little value alone in the average case of intestinal stasis and constipation, because of the various distortions of which the colon is capable.

On the other hand, a well-defined radiograph of the colon by enema would give those familiar with the interpretation of radiographic work a very good conception of the position of the stomach, and any therapeutic application made for the distorted physiology found would apply to both organs.

SINE CURRENT

A very important consideration, and too often overlooked, is the fact that many forms of functional disturbance in the Pelvic region can easily be traced to Colonic Ptosis either Caecum or Sigmoid or both, by X-Ray enema. Such a procedure, before attempting any form of treatment, would present much persistent and useless tamponade and unsatisfactory Surgery.

Amenorrhea, Dysmenorrhea, Uterine Flexions and Versions, Simple Prolapsus due to relaxed Vagina and Vaginitis (non-specific) are examples in Gynaecology.

Rectal Fissure, Rectual Ulcer, Rectal Prolapse and Hemorrhoids, very often are made to disappear when the treatment as outlined in the chapter on Sigmoid has been properly carried out.

Recurrent Cystitis is another example of a local pressure caused by an over distended Sigmoid.

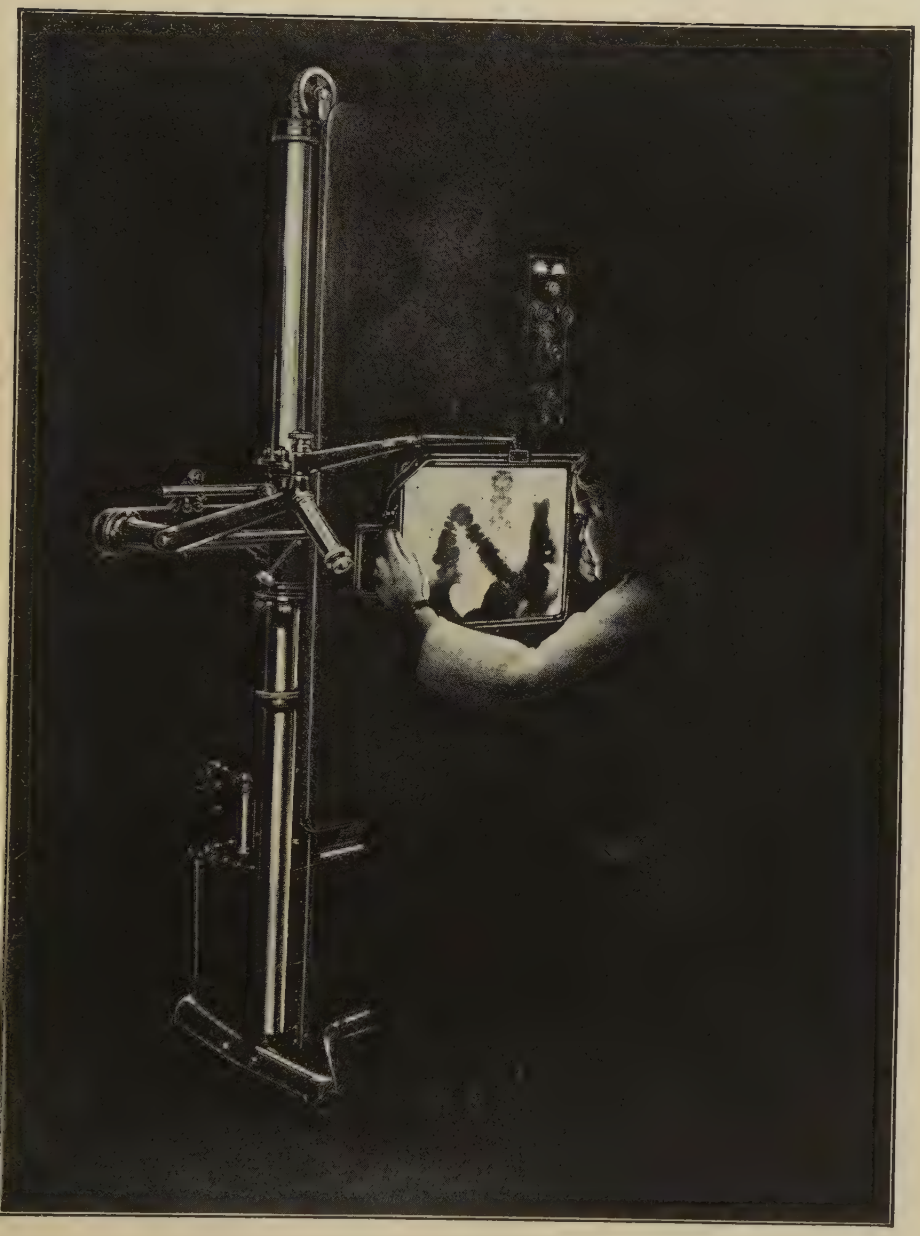
The above illustrations are to emphasize the value of a radiograph by enema, rather than the mouth, for a more certain diagnosis of the ietiology.

Fig. 31

A modern fluoroscope causing sufficient flexibility of adjustment to meet all requirements will give a good general visualization of intestinal topography.

To make it a success however, the stomach and colon should be properly prepared as one would for a radiograph.

The author's usual procedure is, when it is possible, to have the patient take sufficient castor oil at night followed by enema in morning and no breakfast until afterward.



COLON DIAGNOSIS WITHOUT X-RAY

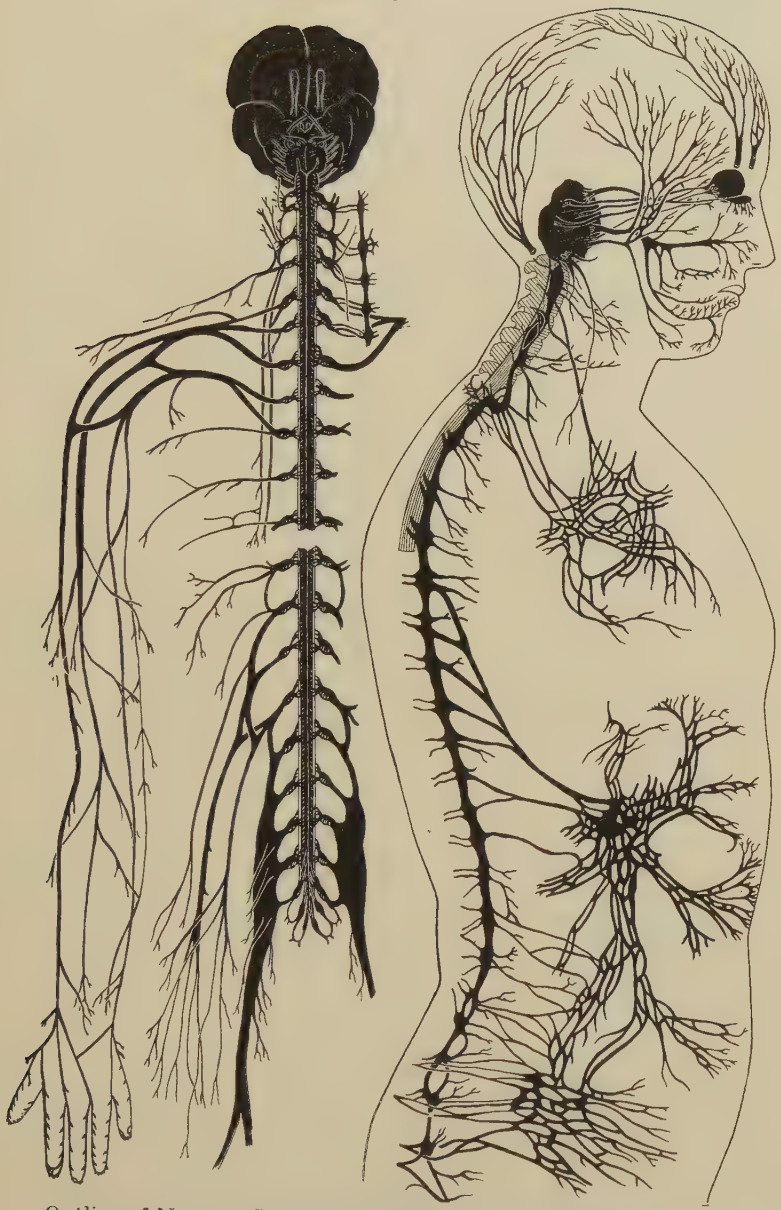
In the absence of a radiograph of the colon, there are certain diagnostic points which are of value and should not be overlooked, even if there is an X-ray verification. Given a patient lying on the back, clothes sufficiently removed to prevent mistakes, commence by percussion over the ascending colon. If it is a case of constipation of long standing, anticipating that the caecum will be distended, a more or less marked tympanitis will be recognized, which will vary in individuals as a rule, according to the degree of angulation at the hepatic flexure, or whether a thin or robust subject, and the chronicity of the constipation. The transverse colon by the percussion method will rarely elicit any information of consequence at the splenic flexure; however, there is usually a dullness in sharp contrast with the ascending colon. If the patient describes an imperfect and faulty bowel elimination, fullness, and if tenderness in the left iliac fossa is present, and assuming the above examination by means of palpation and percussion has been made, a probable diagnosis of visceroptosis would likely be correct.

To verify what seems to be intelligent guesswork, pressure on the region of the right twelfth dorsal nerve and on the eighth left dorsal nerve at its spinal exit, will usually reveal more or less tenderness, which is sometimes very acute, in sharp contrast to the nerve supply above or below the areas mentioned.

In a caecum infection which extends low in the pelvis, the lumbar nerves, which form the origin of the sciatic nerve, are sometimes involved in the infectious process and so-called "sciatica" is often present, which is easily traceable, not only from the condition found by percussion, but by a tenderness extending from the lumbar nerves on corresponding side directly over the course of the Sciatic nerve.

Therefore, the old term "sciatic rheumatism" is frequently infectious sciatic neuritis.

Fig. 32.



Outline of Nervous System supplying Viscera and extremites for a diagnostic help in Traumatism and Intestinal iniectfon.

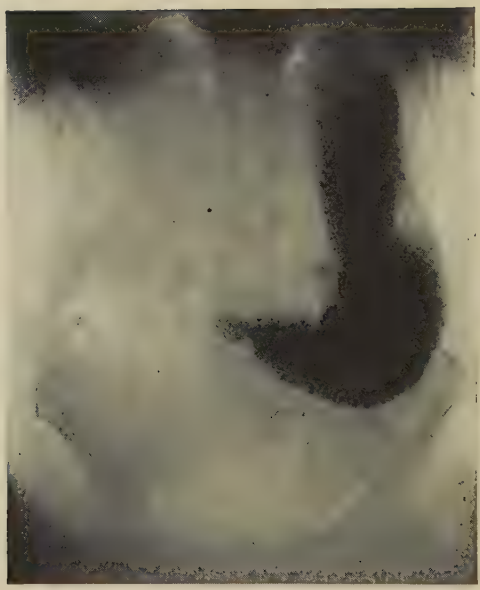
Fig. 33.

This is a Radiograph of a moderately prolapsed Stomach and Colon with sufficient peristalsis to maintain fair elimination. It might be considered a typical Gastro-enteroptosis, which if recognized early and proper treatment administered, much time and trouble would be saved as compared with the same condition a few months or years later.

Fig. 34.

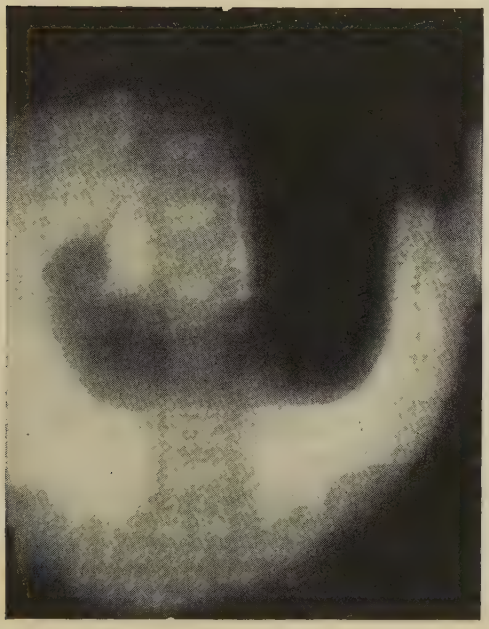
Shows the position of a prolapsed stomach in the Median Line direction, which would likely cause about equal disturbance at the Hepatic and Splenic Flexure; but not sufficiently advanced to affect the Pelvic Colon.

Fig. 35.



The X-ray of a Stomach by barium meal, showing the organ to be in the left Iliac fossa, the so-called fish-hook variety.

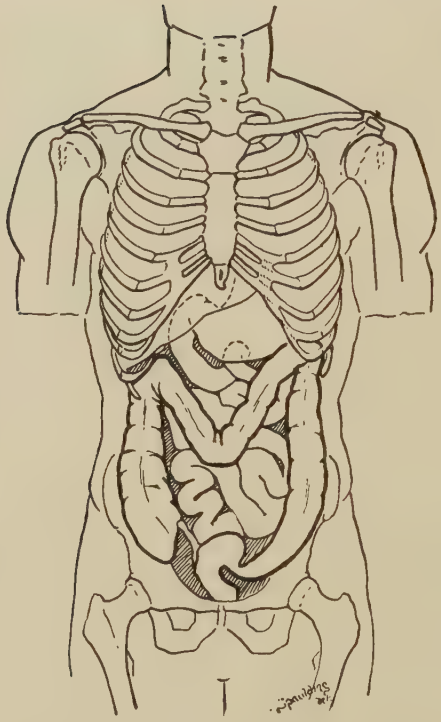
Fig. 36.



Is an example of medium line gastroptosis which alone would not give a clear idea of the shape the caicum or sigmoid where the indications for treatment usually exist.

This is shown for the reason that a single radiograph of the stomach too often is considered sufficient.

Fig. 37.



Shows an example of the Colon, without much apparent Gastroptosis, but a very marked acute angulation at the Hepatic Flexure with a distended Caecum.

OBSTIPATION

Obstipation more clearly defines the condition of the mechanical interference with the normal transmission of bowel contents, and while the stomach may be primarily at fault, it is the colon that gets a deformity, all the way from slight abnormal angles at some of the flexures, to strictures, partial or complete. This condition may also be due to pressure from tumors or other misplaced and enlarged viscera, and adhesions from peritoneal inflammation and the results of abdominal surgery.

That form of proper functioning of the musculature of the bowel so often spoken of by roentgenologists as spastic constipation is usually a symptom due to reflex nervous conditions, possibly connected with Auerbach's *Plexus*, and in the proximity of some physiological or pathological impairment, nerve impulse is transmitted to the muscular fibres that are sufficiently healthy to respond, to produce, and to maintain a local spasm.

Many pages might be written of the etiology and the various existing conditions that lead to faulty, irregular and insufficient elimination of waste material from the intestinal canal. Many authors attach much importance to some impairment of the nervous system, carelessness on the part of a patient as regards regularity, and many other details which have more or less bearing on improper function. Congenital and hereditary influences, in the opinion of the author, should hardly be considered. All agree, however, that the habitual and persistent use of cathartics, errors in diet, and the wrong adjustment of clothing about the abdomen are the important factors to be considered, and with the young and middle-aged are oftentimes corrected by regulation of diet, which is all that is necsssary to restore natural elimination.

The majority of subjects, however, who present themselves to the doctor for relief of one or more of the many ailments, have

as a prominent symptom the inability of the bowels to function properly. If the condition is treated by depending upon the patient's history, without a definite knowledge of the location of the obstipation, the results that would usually follow would be what might be expected from the so-called "shotgun" prescription.

Muscular atony, of both voluntary abdominal muscles and colonic involuntary fibre, are involved and must be considered in outlining methods for restoration. Treatment of abdominal atony can be carried out to more or less advantage by manual massage and by many exercises that the patients can do themselves. Intestinal atony, usually colonic, rarely involves the whole of the larger bowel, but in certain sections, there are well marked defective muscular areas that can be easily verified by the X-ray by barium enema. It is quite apt to be delusive when an attempt at visualizing the colon by a second day exposure with a bismuth or barium meal is made. The principal reason for this is that the angulation at the hepatic flexure is usually so acute and the caecum so distended that there is partial paralysis of its muscular fibre at the splenic flexure and sigmoid. If massage and other manipulations of the abdominal walls to restore tone and overcome the feeble expulsive ability are used, it is still more important that the same principle be carried out where the involuntary muscles have their most defective muscular area. The transverse colon, even if badly prolapsed, often shows well marked peristalsis extending around the splenic flexure, though the angulation seems equally out of position with the hepatic flexure. Fig. 34. Operators who are familiar with the mechanical or electrical attempt at stimulation of the colon, have not failed to observe that much more invigoration, mechanically speaking, is essential on the right side than on the left, because of the local toxaemia there—impairing not only the motor but sensory nerves adjacent.

The treatment of constipation must resolve itself into the recognition of the various factors that enter into its causation.

To make a diagnosis of atonic dyspepsia, "atonic intestinal indigestion", simply gives a name to a symptom, and is in itself, of no special importance.

It is delusive to think that the abdominal viscera are suspended in the cavity by the mesenteries alone, or even with the help of the meso-colon, but they do act to keep the relative position of the intestines and other abdominal viscera, and thus prevent the colon from twisting on itself.

In a normal individual, the abdominal wall is composed of firm, elastic muscles, which maintain more or less constant pressure on the cavity. This pressure, according to Mummery, is estimated to be in some persons ten pounds to a square inch, It is probable that it is always, in healthy persons, more than sufficient to counter-balance the effect of gravity upon the abdominal viscera and that, under normal conditions, the intestines may be said to float within the abdomen, so that no drag is exerted upon the mesenteries. If, for any reason, the abdominal wall becomes weakened, this state ceases to exist, and all viscera are then subject to the effect of gravity and, in consequence, tend to become displaced downward. This is often seen following hysterectomy, and where there has been a sudden loss of fat from the abdomen or the body in general. This is also sometimes seen following child-birth, where the abdominal wall is slow in recovering itself, at which time the liver and kidneys may become more or less loose from their attachments and become prolapsed. Therefore, one of the prominent features existing in chronic constipation, in addition to colonic distortions already described, is the impaired musculature of the muscle layers constituting the support of the abdominal wall; and it is here that abdominal supports, like uterine supports, arch supports, and the like should only be used temporarily as a palliative measure, while something is being done to cause a recuperation of the impaired muscular fibre.

Constipation is chiefly of importance because of the secondary impairment to which it gives rise. The symptoms are very numerous, such as headache, dullness, discomfort in the abdomen, backache, etc., but the most important results of severe constipation is the condition of toxemia called autointoxication. When the contents of the colon are unduly delayed in their passage to the anus, and remain long retained within the body, certain alterations take place. Chemical changes occur in the fecal material and many of the waste products of indican become still further split up into poisonous substances or toxins.

Under normal circumstances there would not be time for the formation of poisonous by-products before the faeces are discharged from the body; but in chronic constipation considerable quantities of these may form while the faeces are still in the colon, and then be absorbed by the bowels and find their way into the blood-stream. The patient, in fact, is slowly poisoned by toxins formed within his own colon.

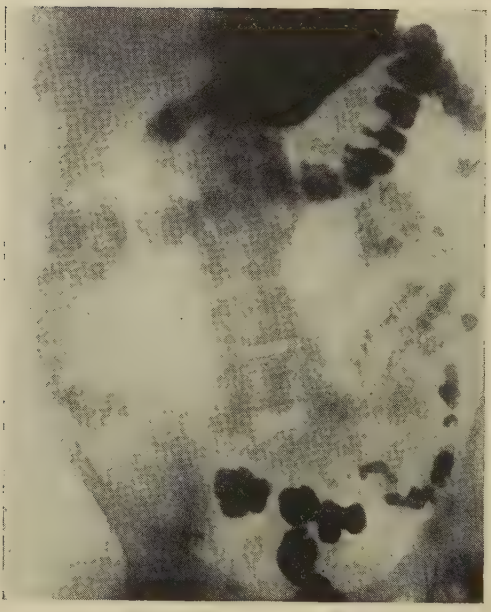
We have good evidence of the extremely poisonous nature of these toxins in cases of intestinal obstruction. Here, when death occurs, it is more often due to a profound toxaemia from the poisons generated within the obstructed bowel than from the obstruction itself.

The toxaemia in chronic constipation is never so serious or profound as in intestinal obstruction, because the poisoning occurs more slowly, and the bowel wall being undamaged, absorption does not occur so readily. It often, nevertheless, produces, after a time, very serious consequences.

Fig. 38.

By barium enema, shows a second example of the colonic distortion, with a moderate abnormal Hepatic angle, but much distended Sigmoid. Here also is a disarrangement of the normal position where indication for treatment as outlined would apply.

Fig. 39.



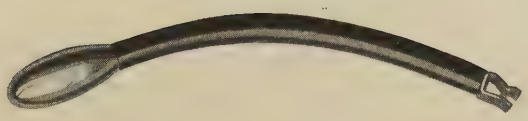
Shows a "better than usual" Colon picture, by barium meal taken after twenty-four hours. Also stomach by barium meal taken at the same time.

Fig. 40.

Figs. 40 and 41 are to illustrate the value of the Radiograph by enema rather than by mouth in the majority of cases where the colon is at fault incidentally before and after treatment cases.

Fig. 41.

Fig. 42.



Sigmoid Electrode.

Fig. 42 shows the usual form of Sigmoid electrode, made curve to better conform with the part for alternating Sine Current.

Fig. 43.

Bi-polar rectal electrode.

Fig. 43 shows a bi-polar rectal electrode that may be used in conjunction or following the usual Sigmoid electrode in the lower bowel, either for relaxation or prolapsus; produces local invigoration with the alternating sine current.

CAECUM INFECTION

There is probably no part of the body of which there has been so much written and on which so much useless surgery has been done, as in the region of the appendix.

Acute appendicitis, with its well-marked symptoms, both constitutional and local, is almost invariably a call for surgical action. This is especially true in young and middle-aged persons where inflammatory processes often pursue a rapid course, but in the older subject, where there exists what is called recurrent or relapsing appendicitis, appendectomy is in a large percentage of cases unwarranted, based on observation and long experience in Abdominal Radiography.

The position of the appendix is such that when the caecum becomes distended and toxic, it mechanically becomes irritated through friction with the internal crest of the Ileum. The return of the same symptoms that preceded the operation for the removal of the appendix, the recurrent or so-called chronic case, is so apt to occur from six months to a year, that it makes the patient feel, and the doctor possibly think, that the operation was not necessary. Figs. 41 and 45.

A barium enema, showing sharp angulation at the hepatic flexure, the still distended and infected caecum, with a possible ileal stasis, usually explains "why" they think so. The apparently strong statement made might not be justified, if the author had not seen several hundred cases following apendectomy, where the pre-operative symptoms returned and were relieved only when the hepatic flexure was changed from a threatening kink to a more obtuse angle by means of mechanical therapeutics.

It is unfortunate that too often the surgeon feels that if the patient leaves the operating table and the hospital alive and comfortable, the hospital and doctor having been financially rewarded, the operation was successful.

To be sure, during the hospital care, with the post-operative rest, and caution as to over-exercise and diet, the sufferer naturally feels benefited, but when he goes about his business again and takes up active work as a healthy person would hope and expect to do after a surgical session, and has a recurrence of the pain and tenderness in the right side, it is most lamentable and discouraging.

The above is no over-drawn picture, no exaggerated statement, and it is in keeping with the reports of many of our most prominent surgeons that eighty percent of the cases of chronic appendicitis, so-called, should not be operated upon. The modus operandi here employed by the sine wave (alternating) surging treatment should be used with caution about the caecum where diathermy has just been applied, and tenderness is present.

Fig. 41.

A Gastro-enteroptosis mechanically producing a sharp angulation at the hepatic flexure and consequent caecum distention and toxiema.

COLITIS

The term "Colitis" is usually applied to catarrh of the colon, and often it is simply diagnosed as mucous colitis, which may be an "ulcerative" or "membranous" form. Colitis, because of the character of the prominent symptoms, is looked upon as something that is of the nature of a "diarrhea" or "dysentery", that should be checked or controlled, while, as a matter of fact, it is a case of constipation, and the irritation thus caused manifests itself as above described. Radiographic findings, along with other prominent symptoms, make the condition easily recognizable, also a modern electric-lighted proctoscope materially assists in verifying the diagnosis.

The jelly-like discharge so often recognized, caused by the catarrh of the mucous membrane of the colon, is frequently hard to control, as it is one of nature's efforts to get rid of existing toxaemia, which is ever present, and will usually continue, regardless of diet and topical application, until the mucosa of the bowel is so restored in its integrity that it will resist further invasion of the disastrous bacteria. In aged patients, and those of feeble resistance, colitis, unless checked, is likely to lead to diverticulitis and other degenerative changes, and malignancy is usually the sequence.

Diathermy through the entire colon, accompanied by not too vigorous wave current surging treatment through the caecum, with frequent ultra-violet radiation front and back, has often proved efficacious because of the elimination of the bacterias that were continously producing the manifestations in the form of a characteristic product of the infection.

The results of sine wave current treatment will depend largely on the condition of the caecum as far as that portion of the colon is toxic.

It should hardly be expected that the descending colon and sigmoid would be made healthy until the toxic bacteria of the caecum had practically ceased to exist.

Therefore, the treatment resolves itself into diet, local medication and restoration of the tonicity of the musculature of the damaged area.

ILEAL STASIS

Sir Arbuthnot Lane, of London, was the first to bring before the profession a better interpretation of stasis as applied to the intestinal tract.

The word "stasis" has been adopted by writers when referring to any part of the intestines where there has been an inflammatory process, or a retention of eliminative material sufficiently long to have gone through putrefactive processes and resulting infection.

The term, therefore, is a broad one, and to elucidate the subject thoroughly it must be localized to a nicety, or any guide directed to treatment thereto will lack the definiteness which is so essential to the best therapeutics.—Fig. 40.

When a stomach becomes prolapsed, which process is usually over a period of years, certain changes take place in the adjacent tissue and sometimes the surrounding viscera. The right kidney is often misplaced, the duodenum becomes not only depressed but distorted, and consequently its calibre made smaller, and the foundation for future trouble is thus inaugurated. Fig. 34.

The stenosis thus caused may bring about a chronic duodenitis, usually further adding to stomach dilation, because of the longer retention of food therein. The stenosis may become so severe that the only relief is a quick resort to gastro-enterostomy. Duodenal ulcer is another consequence of gastroptosis, and if recognized early enough in young and middle-aged subjects, a

rigid diet, the proper use of galvanism, diathermy, and ultra violet light, may prevent surgery. In the older subject, where general intestinal toxaemia exists, malignancy is very apt to follow.

As has been outlined by the examination of the abdomen for localization of toxic areas, that might explain certain symptoms, plus a verification by X-ray examination, by those who are familiar with the interpretation of radiographs, it should not be difficult to localize the toxic area.—Fig. 45.

Ileal stasis, which as explained necessarily is an ileal toxaemia, and produces certain ill-defined symptoms that are not easily traceable to a source except by X-ray Enema.

Lumbar and dorsal arthritis, and general autointoxication, are often terms applied to indefinite and painful symptoms. Arthritis of the smaller joints, especially the fingers, is often noticed where there is no other manifestation throughout the body, and after teeth, tonsils, gall bladder and colon have been inspected the physician often is at a loss to determine where the poison comes from.

As mentioned, an X-ray of the intestinal tract, taken by barium meal, will not reveal ileal residue as would be determined when taken by barium enema; which still further goes to prove the importance of the method to determine this particular condition.

The physical measures resorted to, in addition to what has been mentioned, will be mechanical invigoration of the stomach, using the technique that would apply to treating the angle of the colon for constipation.

Fig. 45.

Fig. 45 shows a colon with such a sharp angulation at the Hepatic Flexure that the over-distended Caecum has caused muscular deficiency at the Ileocecal Valve, as shown by the presence of barium in the Ilium, a condition recognized as Ileocecal incompetency, and consequently, Ileal stasis.

Fig. 46.

Fig. 46 shows a condition similar to that shown in Fig. 45 with the exception that the Ileocecal Valve is intact. Same case after treatment by alternating sine wave.

Fig. 47.

Radiograph by barium enema, with well-defined Ileal stasis in a nearly perfectly formed Colon. The patient's symptoms were Arterial Hypertension (186mm), constipation, and more or less general Arthritis.

Fig. 18.

Fig. 48 shows the Radiograph of patient as Fig. 47 after three months treatment with the Sine Wave Current through the ascending and descending colons. It is to be noted that there is a decided improvement in the muscular appearance of the entire colon and a complete restoration of the incompetent Ileocecal valve, and it is quite unnecessary to state that the arterial hyper-tension, constipation, and Arthritis, which were present were entirely relieved and after five years there has been no return of the symptoms.

Fig. 49.

A woman, 55, radiograph taken by barium enema, November 14, 1920. The picture shows well marked Ileal stasis and Diverticulitis of the descending Colon with a distortion that might be almost considered pre-cancerous. The appearance of the tranverse colon showing the smoothness, consequent atony is conspicuous. Constipation very severe and the patient complained of Arthritis in the right knee and Neuritis in the right facial nerve. Blood pressure 198. The general appearance was one of marked autointoxication with corresponding general lassitude.

Fig. 50.

Same picture as Fig. 49 after 29 days, during which time sixteen treatments were given. The relief of all symptoms was very marked in one month, i.e., five carthartic pills daily were superseded by a tablespoonful of mineral oil twice daily; blood pressure reduced from 198 to 172, and all painful symptoms relieved. The incompetent Illeocecal Valve was apparently nearly restored and a tonic appearance was in evidence throughout the whole colon, where previously existed marked atony. The restoration of the tone of the parts is easily recognized. Arthritis, Neuritis, and Constipation were much relieved. The radiograph was taken Dec. 11, 1922 after sixteen treatments. The Lesson to be learned from figure 49 is that a pre-cancerous condition existed in the descending Colon. Fig. 50 shows a relief in the "kink", thus surgery was avoided. The patient died in 1926 of Myocarditis and the attending surgeon informed the writer there was no return of the auto-intoxication or the necessity of drug carthartics.

The lesson to be learned from such results is sufficient to warrant one's going ahead with the treatment by surging wave currents even if the prospects of much benefit are discouraging. With high Arterial tension existing in the case described, combined with a general toxic condition throughout the body, the patient could hardly have been expected to survive the proposed operation for the removal of a portion of the descending colon, which surgically seemed to be indicated.

Fig. 51.

Radiograph by barium enema, showing Ileal stasis where the appendix had been removed one year previous.

Fig. 52.

Fig. 52 shows same picture as Fig. 51 after four months' treatment showing improvement in the general tone, of the colon is noticed with a relief of constipation and existing Arthritis. This is one of the hundreds of similar X-ray pictures which the authors' files show, as a proof of the advisability of not operating for chronic Appendicitis just because there is a pain in that region, until the position and condition at the Hepatic Flexure has been ascertained.

THE SIGMOID

One who has read the recent writings of such physiologists as Alavarez, Rabachow, and Cannon on the mechanics of the intestinal tract, and the way in which function is impaired when the original mechanical program is interfered with, should easily understand why, in a larger proportion of cases of intestinal toxaemia, the sigmoid plays such an important part.

Nearly twenty years ago, Dr. Gant, of New York, wrote a volume on rectal diseases, in which he devoted one short chapter to the relation of the colon to diseases and impaired function in the sigmoid and below. Recently, the same author has given to the profession three elaborate volumes consisting of over fifteen hundred pages on the same subject, and he has written nearly five hundred pages on the colon as a factor of importance in diseases of the sigmoid and rectum.

The significance of this, from such an able authority, gives great credence to what is said in this book on the importance of localizing the toxic areas of the colon.

When outlining a therapeutic procedure, physicians doing radiographic work in conjunction with physical therapeutics have frequently observed adjacent viscera relieved and apparently cured, that seemingly had no relation to the sigmoid—and the author has seen it verified daily in his own office work. This applied to cystitis, hemorrhoids, irritable prostate without enlargement, and some forms of uterine displacements. It has been repeatedly observed where the persistent use of uterine pessaries, tamponade, and topical applications within the rectum and vagina fail to produce results, that with the restoration of the position of the prolapsed sigmoid it has been given tonicity, and just in proportion as the prolapsed pelvic colon has been relieved of its impaction and sagging, these patients have been free, in a degree, of the previous distressing and painful pressure symptoms.

This, of course, does not apply too generally, because surgery has its place and must be respected. But, like similar conditions, removing the symptoms without removing the cause is quite apt to bring a recurrence of the trouble, with disappointment for all concerned.

Fig. 53 is a good illustration of a sagging and at times impacted sigmoid causing not only local and general infection but more or less pain and other symptoms by actual pressure.

Fig. 53.

Fig. 54.

Same case as Fig. 53 after Rectal treatments by Alternating Sinusoidal Wave methods. The sharp angulation below the Hepatic Flexure was of a traumatic nature (old adhesions) independent of the Sigmoid for which the cut is used.

Fig. 55.

Radiograph of the Colon by barium enema shows a very marked prolapsus of the Colon through the left Iliac Fossa, extending to the crest of the Ilium, indications that the stomach prolapsus, which shows the primary cause, must have been of the "fish-hook" variety. Sine Wave Current administered through the Hepatic and Splenic Flexures, alternating with a Sigmoid electrode, gave quick relief. See Fig. 42.

Fig. 56.

The results of treatment of Fig. 55 are shown in Fig. 56, blood pressure was reduced from 210 to 162, carthartics discontinued because not needed, and relief of usual distressing symptoms that accompany high arterial tension. Any surgeon or one familiar with radiographic teachings can easily see such a condition was drifting toward malignancy. Therefore, it is fortunate if these and similar conditions can be discovered and treated before the existing toxemia produces the common results; namely, nephritis, myocarditis, and an earlier demise before degenerative changes take place.

Many intestinal radiographs may be copied from the author's X-ray films, still further illustrating the importance of recognizing where it is essential to change certain kinks to curves; however, the foregoing illustrations for one who is at all familiar with the interpretation of visceral radiographs should be sufficient to see the importance of such teaching.

Fig. 57.

Barium enema of the Colon, represents a sharp angulation of the Hepatic Flexure, with depression of the tranverse Colon into the left Iliac Fossa, after four months' treatment through the Hepatic Flexure with small electrode in front and larger one on the dorsal region, followed by a large surface electrode in front over the descending colon and using the Sigmoid electrode.

Fig. 58.

Fig. 58 is the same patient as described in Fig. 57 having received twice-a-week treatments by the Alternating Sinusoidal Surging Current through the Hepatic and Splenic Flexures, also per rectum with the Sigmoid Electrode. The Constipation, and painful pressure symptoms were removed; the blood pressure which was 214 at the beginning of the treatment was 154, when the second Radiograph was taken four months later. One can draw on their imagination what the patient's condition would have been if a functional restoration of the colon had not been instituted.

Fig. 59.

X-ray of the Colon, showing a complete Enteroptosis extending nearly to the pubes. The severe acuteness of the angle at the Hepatic Flexure with the distended Caecum, indicates that something along radical lines should be done to prevent possible malignancy in the near future; the age, sixty, and diminished resistance of the patient prohibiting any effort by surgical means and restoration of partial function by physical effort would be all that could be reasonably hoped for.

Fig. 60.

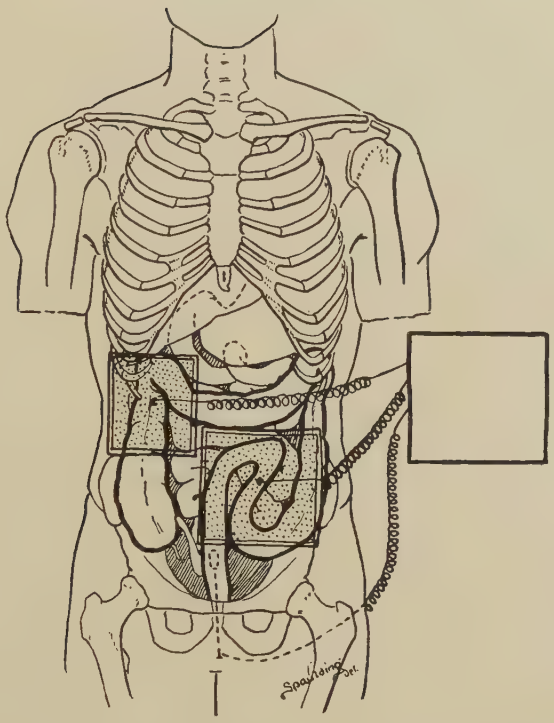
Fig. 60 shows the same patient as Fig. 59, taken three months later, having received two treatments weekly by the method described elsewhere in similar prolapsus of the stomach and Colon.

Fig. 61.

Taken by barium enema one year after Fig. 59 and six months after Fig. 60, shows a still more proportional increase in volume. In the meantime, the patient (a lady of sixty years of age) had improved in weight, strength and general appearance. The results do not show very marked anatomical change, but as the physiological function was much increased, this proves the effort toward restoration was not entirely futile.

On the principle that modern scientific medicine is preventative medicine, this seems to be the kind of a case where much may be done to prolong life and prevent what would seem inevitable, namely malignancy in or about the region of the Hepatic Flexure. The inadvisability of surgery in cases of this type is obvious; the continuous use of cathartics, the inability of abdominal supports to do anything other than harm, behooves the physician who has his patient's interest at heart to make an effort with the modern means at his command to try to restore some lost muscle tone, or else throw up his hands and say "it is the will of God" and let the poor soul slide into Eternity via the malignancy route without an effort to prevent or retard the degenerative changes, where a sufficiently sharp bowel angulation obstructs circulation.

Fig. 62.



In Fig. 62 will be seen an illustration of the Surface Electrodes for treatment of conditions of abnominal colonic angles. The technique as to size and position of the abdominal electrodes must necessarily vary with conditions present. For instance an electrode over the Hepatic flexure 4 by 6 inches on a tall subject would be indicated while short person would require only a 3 by 4 inch size. The dorsal surface electrode should always be larger and at a higher level than in front that the desired impulse may be parallel with muscular and nerve distribution. The rectal electrode should be used with the largest size moist surface electrode so that the Sigmoid may have a concentrated effect. The cut, as might be imagined, does not mean that all three cuts be used at one time, but it could hardly be arranged otherwise to explain the modus operandi.

GALL BLADDER INFECTION

Disturbances in and about the gall bladder region have been recognized for a long time as a separate form of infection that calls for special diet; they are sometimes relieved by certain medicines; and the region is frequently the site of surgical intervention.

The pathology existing may be that of gall stones, malignancy, extensive duodenal ulcer, inflammatory processes extending from the appendix, or possibly a pancreatic disease of some kind.

The X-ray sometimes does, through oftener does not, reveal the presence of calculi. Cholecystitis is a condition of infection before the stage of bacterial changes in the bile itself, or possibly degenerative changes in the walls of the gall bladder, leading to actual formation of calculi.

The writer has repeatedly observed cases of infected gall bladder relieved and apparently cured of all symptoms after a toxic caecum of long standing is overcome.

The usual diagnosis by palpation, percussion, and the history of the case is very apt to be misleading as to the true condition, and also as to whether it is the gall bladder *per se* or toxaemia in the immediate region, which is the real cause of the disturbance.

Recent discoveries of better X-ray methods by the use of sodium tetraiodo phenolphthalein shows the outline to a greater nicety of the area of gall bladder distention, which permits sharp distinction between surgical and non-surgical indications.

Dr. Burton B. Grover, of Colorado Springs, and others have reported quick relief and apparent elimination of symptoms by the use of the surging wave current. The effect, of course, was purely mechanical, and the result obtained must have been brought about by restoring the tone of the muscle walls weakened

through the infectious process, as might apply to intestinal stasis or any other portion of weakened muscular fibre from any other cause.

It can be easily seen that there are many conditions where the method would be harmful, but when calculi, malignancy, and the like have been eliminated, the method is worthy of consideration.

The application of the sine wave current through a gall bladder may be the cause of immediate pain or extreme tenderness with or without actual pain, that may last for several days. Should there be such an occurrence, it would be wise to relinquish treatments at once and make absolutely sure that gall stones are or are not present. The very fact that a deep mechanical action was produced will often elicit the information that gall stones are present, or that there are indications of such a nature that further applications should be discontinued, or used later after acute symptoms have subsided.

In making application through the gall bladder, using the usual moist electrodes with the larger one on the back, it would be good technique to have the dorsal electrode placed higher than the usual application for treatment of caecum infection as described elsewhere.

COLONIC FLUSHING AND INTESTINAL IRRIGATION

Irrigation of the colon by flexible rubber tubes of different lengths and sizes is called by some manipulators of the method "colonic flushing."

The usual process, and the one to which the writers refer, consists of an apparatus whereby large glass reservoirs containing three to five gallons of water, adjusted by gravity apparatus to maintain a constant pressure through a tube sufficiently large that the returning fluid may, by adjusting a valve, be deflected into a receptacle where the contents may be examined if desired. Salt or any medication may be added to the water as the conditions indicate.

Fig. 63.

Is a design of a Colon flushing apparatus by means of which a cleaning of the colon, especially the pelvic portion, is accomplished in a very thorough manner. There are other and more elaborate designs obtainable but the principle is the same.

Physicians and others doing this form of colonic cleansing claim almost universally good results in arthritis, high arterial tension, and many other conditions where colonic toxaemia is the apparent cause of the symptoms, painful or otherwise.

The late Dr. Seltzer of Philadelphia carried out the above program in all his cases of intestinal toxaemia, and in addition, he followed the flushing by the use of alternating wave generator surging treatment as has been described, claiming that his results were double what they would have been had he used either method alone.

The principle is plausible, and where it can be so arranged to use the double method as referred to, it certainly lessens the time of treatment for the relief of constipation.

Water is an essential constituent of the living organism and must be constantly supplied to replace that which is being lost. The chemical changes taking place in the tissues are reactions between dissociated molecules in a weak saline solution. Hence, any considerable drying of the body would arrest all vital processes. When a man is deprived of food, he is able to live for a considerable period upon his own tissues.

The elimination of water takes place in the urine and faeces and from the skin and lungs. The tissues retain approximately the same quantity in health, so that with a sufficient supply, the amount of water lost is determined by the amount taken in; if enough water is not available to make up the minimum loss, thirst arises.

Variations in the loss of water are chiefly due to evaporation from the skin, for this is the means by which any excess of heat is dissipated, and the temperature kept constant. The amount of water in the urine, if the diet be the same, will vary inversely as the loss from the skin, and therefore in hot weather the urine is scanty, and in winter, abundant. The total loss of water from all sources is rather more than the quantity taken in the food, for the oxidation of the hydrogen of the solid wood produces

a half pint or more which must be eliminated. The average quantity evaporated from the skin and lungs in a day is about a pint and a half, two-thirds of which is given off from the skin; this total increases very much with active movement and may be over half a pint in an hour, i.e., ten times as much as is lost in that time during rest. The drinking of an increased quantity of water does not, apart from muscular exertion, lead to a greater evaporation from the skin, but the extra quantity appears in the urine,—that is to say, other things being equal, water has a direct diuretic action. The evaporation from the skin is determined during rest by the needs of the regulation of heat and not by the amount of water taken in.

It is a well-known fact that the average person does not drink a sufficient amount of water. It is also true that a large proportion of people living in cities and large towns depending upon the city water supply for their drinking water, which unless cooled by ice or allowed to run a considerable time from the faucet before taking, is usually more or less unpalatable, the result is that tea, coffee, and other decoctions and concoctions furnish the daily amount of liquid taken into the system. People living in the country where deep well and spring water is more available, doing different kinds of labor causing more or less perspiration and thirst, which is offset by large quantities of pure water, are less likely to have intestinal poisoning and its many sequences, such as the so-called rheumatism, arthritis, neuritis, and constipation.

It is noticed that young and middle-aged persons who are chronically constipated, as they call themselves, and are habitually addicted to the use of cathartics during a greater part of the year, find that during their summer vacation in the country their constipation is forgotten, which condition often continues for several weeks after their vacation is over.

The body is constantly producing heat and giving out heat, and the mechanism is so marvellously arranged that the temperature of the whole system is adjusted so as to be higher than that

of the surrounding conditions, and from time to time it is necessary that the body should take into itself certain substances known as food, being in the main similar to those which compose it and through chemical efforts and oxidation, change into energy to be utilized where most needed.

So much for the first part of the metabolic process. The other consists in the elimination of waste matter and deleterious substances which may be broadly described as the products of oxidation of the substances taken in the food or decomposition of parts of the body itself.

Hence, the living structure to maintain normal nutrition must not only take in and assimilate in proper proportions materials for repair, but deterioration, which may be called under the heads of congestion, inflammation, and over-retention; the result of which is to disarrange the original plan of a healthy mechanism from maintaining its equilibrium.

Now when these abnormal conditions occur externally in the form of acute inflammation, abscess, some skin affections, and where proper medicinal applications or surgery might easily control the situation, the solution is simple. But when non-purulent infections invade the inaccessible areas, which we call tissues, and which may come under the head of muscular, nervous or connective, as variously arranged in different organs, then the process of getting rid of the local stasis before it has time to cause secondary degenerative changes is the most important consideration of the physician.

Without being too comprehensive,and elaborating, upon the various positions and conditions of localized intestinal stasis, from the most prevalent and perhaps better understood example of defective elimination, so long as these local stases, usually due to errors in diet, occur in young, middle-aged and healthy subjects, nature, with her wonderful powers of recuperation, elasticity and protective lining of the digestive tract, may adjust itself, and the slight disturbance is passed over and forgotten. However, in the

less fortunate, as far as diet, nature of occupation and construction of the body is concerned; or in older subjects, whose powers of elimination grow less and less, and ability to absorb more and more, the condition changes from one of physiological activity to pathological significance, and before it has become a surgical necessity, then is the chance for the physician to step in and either prevent or defer the inevitable.

Therefore, a pure assimilative water in sufficient quantities so that the tissues become fairly saturated, and while in situ, mechanical stimulation in any form the physician thinks best or has at hand, will not break down adhesions and cure ankylosed joints, but will do what drugs can not do, and more than if the same mechanical or electrical process were instituted, and the tissues under consideration practically starved for the want of nature's own solvent to help set free the poisons.

Even the systematic drinking of ordinary water is employed for remedial purposes. In this connection, weight must be given to the thermic and chemical effects of the water which have an influence directly upon the organic economy and the temperature as well as upon metabolic processes.

Water, when introduced into the stomach, is readily taken up by the body. It remains in relation with the body for a considerable period of time, and through the stomach and the intestinal canal it enters into direct contact with the most diverse portions of the digestive apparatus. By reason of the equalization of its temperature with that of the body, as a result of absorption into the fluids and the blood-mass, and by reason of its chemical constitution, water must have an especial effect upon the most intimate nutritive processes. When taken internally, water will play an important role, also as an inhibition material, inasmuch as it enters and penetrates all of the tissues and their interstices, and renders them permeable to water-soluble substances.

The nature of the diet has considerable influence upon the amount of water excreted by the kidneys. If an excessive protein

diet is used, a greater quantity of water should be drunk. This is because the nitrogen of the protein food is excreted in the urine in the form of urea, uric acid and other substances, and it involves less work upon the kidneys if these and other excretious substances be sufficiently diluted to prevent the irritation. On the contrary, a strictly vegetarian diet, containing but a small amount of nitro-genous food, requires less water. It is a clinical fact that a large proportion of cases of intestinal stasis is the result of wrong eating, in which an excess of meat was the principal factor of causation, and after the unphysiological changes have taken place at different areas along the digestive tract, notably in the colon, the internal use of a considerable amount of water is strongly indicated; and to pursue the subject still further if distortions, bends, folds, etc., approaching the possibility of kinks, are in evidence, making the area of infection more isolated and marked, the use of water to offset destructive action is again still more strongly indicated.

Hydrotherapy, because of promoting more than usual skin elimination becomes of great value in visceral stagnation.

Soiled clothing allowed to be immersed in ordinary cold (faucet) water will show more or less discoloration in the water when the clothing is removed from same. If the same process were repeated with hot water, on account of the expansion of the heat the effect would be more marked. If, again, under the same conditions, soap were added, the result would be increasingly noticed. And still further, if the hot water and soap were violently agitated, as for instance in the modern electric washing machine process, the maximum of efficiency would seem to have been reached in the cleansing process.

Likewise, a patient may have only a local infection of a fibrosis, but the general appearance from a facial expression to a general lassitude indicates a widespread toxic distribution. It is in this class of cases that its value is shown, and the above simile of clothes washing can to an extent be duplicated within

the human body by proper procedure and an assimilative water, which means a water devoid of as much as possible of chalybeate or other mineral content sufficient to hinder quick absorption in the tissues.

Poland Spring water, with which writer is very familiar, is an example, having but a minute quantity of mineral with a mild alkaline reaction. Such water when obtainable, if freely drunk and used for colonic irrigation, combined with the sine wave current technique as outlined for the treatment of ileal and colonic stasis, will certainly enhance the restoration process greatly.

Statistics tell us that only about 2 per cent. of stomach troubles are the result of stomach disease per se, but rather of the duodenum or furhter down the intestinal tract. Ordinary gastric lavage has no effect whatsoever on the duodenum, no more than colonic flushing would have on the ileum side of the ileocecal valve. Therefore, the usual methods employed for local stomach washing can not be instituted in the duodenum, jejunum or ileum.

Assuming that it is essential that the infected areas of the larger proportion of cases of intestinal poisoning should be thoroughly cleansed as a part of the treatment, as should be done in cases of naso-pharyngeal infection, the process to which the reader's attention is called seems to answer a question that has long been before the profession.

Various circumstances have an influence upon the rapidity of the aborption of water. The lower the degree of tension in the vascular system, the more rapid under otherwise like conditions will be the absorption of water into the bloodvessels. After considerable loss of fluids, as by diarrhea, hemmorrhage, profuse sweating, copious elimination of urine, or other normal or pathologic process, more rapid absorption of water from the intestinal tract will be observed. Water holding less saline matter in solution is more readily taken up into the blood stream than water containing much saline matter. Free alkali increases

considerably the attractive power of a fluid, especially for one with a feeble acid reaction. Thus, a fresh water rich in carbon dioxide, and deficient in saline matters, is likely to be most rapidly absorbed, and is particularly suitable as a beverage. Water containing saline matters is absorbed much more slowly, and will therefore cause a sense of pressure and fullness in the stomach, even when taken in small quantity.

Giving due credit to the institutions where hydro-therapy is the principal treatment, and admitting the great benefits to be derived therefrom in increasing metabolism, thereby relieving painful affections, much more may be done by the internal use of an assimilative water under proper technique. To make some crude comparison, let us imagine an ordinary parlor that is swept, dusted and washed sufficiently often to give the room an air of respectability and cleanliness, and yet back of the furniture and pictures there is the undisturbed, accumulated dirt and dust which is removed only at the annual or semi-annual cleaning, which to a certain extent is always a menance to the air passages, compared with the same room's having the dirt removed as thoroughly from the invisible as well as the visible areas, this would be comparing the healthy washing of the body and leaving areas of intestinal stasis to poison in ordinary accessible areas. Therefore, it is the author's intention to present to you the claim that an assimilative water, a water devoid of sufficient mineral matter so that it can be absorbed in large quantities, and then by process of agitation and exercise so that elimination of the waste products of the deeper tissues can be augmented, as in no other way, the kidneys and bowels could be made to do their own appointed share of work, less would be required of the skin, and the lungs and infections which cause so many diseased conditions could be prevented. This is not a fancy theory that is presented to the reader, for the writer has had opportunity for several years of using a water that is so pure that large quantities can be taken, with results which have been so pleasing that it is worthwhile to bring the subject to the reader's attention.

There may be other pure waters in the various regions where people live, besides, Poland water, which answers the purpose for illustration, as it is recognized as being devoid of objectionable substances, consequently readily taken up and absorbed.

The internal use of considerable quantities of water has only been touched upon in literature on the subject as might apply to drinking, colonic flushing, which is all right as far as it goes. From observations of hundreds of cases during the past fifteen years, during which the writer has given the subject of intestinal poisoning special study, he is thoroughly convinced that definite and scientific mechanical manipulation of the abdomen, after large quantities of water have been taken, enhances the beneficial action.

CHAPTER III

Inflammatory Exudates—Extravasations—Infiltrations and Indurations—Physical Treatment of Foot and Ankle Distortions—Hypertrophy of Prostate—Obesity.

INFLAMMATORY EXUDATES

The viscera of the various cavities of the body, cranial, spinal, thoracic, abdominal, and pelvic, as also muscles, tendons, and nerves, are enveloped in shut sacs, containing normally serous fluid sufficient for purposes of lubrication. The articular cavities are also lined with a serous membrane, providing a similar lubricating fluid for the joints.

In acute or chronic, primary or secondary inflammation of any of these serous sacs, an excess exudate occurs. In acute or chronic inflammatory disease of any of the organs, covered by serous sacs, these sacs may become involved with the same results,—an excess serous exudate.

Post-operative organized exudates are the result of trauma, in the course of surgical procedure, or the result of post-operative sepsis.

Post-acute inflammatory effusions, and the post-operative exudates, organized or unorganized, infected or sterile, play a most conspicuous role in the tragedy of disease and are most important factors in the production of chronic pathology.

Termination of acute disease by crisis favors rapid absorption of inflammatory products; termination by lysis favors chronicity and organization of these products.

Nature, in many of the cases of acute primary disease, is entirely adequate to the task of absorption of her serous effusions, but as often conspicuously fails; and, since a successful outcome of the unaided efforts of nature to remove the exudate can not be foretold, it is well to assume that she can not, and to proceed upon that assumption. It is here that galvanism and diathermy are oftentimes used, followed or combined with the sine wave current, with desirable results.

PHYSICAL TREATMENT OF FOOT AND ANKLE DISTORTIONS

The tone of the muscles varies widely, not only in different muscles at the same time but at different times and circumstances. Among the causes for this variation are: defective original development, different states of energy, and degrees of cause through injury and disuse of the muscles.

Anything that tends to impair muscle action in the region of the foot is likely to cause deformity, much or little. Flatfoot or any other malformation below the ankle, unless it is through injury, is of a mechanical nature.

It is essential that the muscular and ligamental structure about the foot and ankle, more than any other part of the body, be maintained at its highest point of efficiency.

Artificial support, when adopted or applied to a part for one reason or another, may be used as a temporary measure, when the foot is no longer able to perform and maintain its customary work.

As it is natural for the foot to have a flat surface to walk on, footwear should be made and adjusted accordingly, so that in walking the muscles that take part in that performance can have the best possible leverage.

The use of arch supporters, etc., constructed in the shoe, or removable or temporary strapping to relieve some part where the pressure is painful, is of necessity often resorted to, but the real cure of flat-foot and similar conditions described, is the training of the muscles responsible, so that they will regain the prehensile power of the foot.

The usual procedure by squeezing, pulling, twisting, and rotating the muscles of the foot, under the name of "massage," is efficient to a degree if long persisted in.

The use of the sine wave current preceded by galvanism or diathermy, lengthwise not crosswise, on the defective muscles and ligaments when adjusted to the normal action of the muscles of the part is, in the hands of those who are familiar with technique, a more satisfactory procedure.

HYPERTROPHY OF THE PROSTATE

This is a condition that calls for careful discrimination in regard to whether it would be wise to treat the case or refuse to do so. A chronic prostatitis that has advanced to a stage where malignancy is probable would be aggravated by any form of treatment, and it is for surgery and radium to do their best and "hope they have discovered it in time." The usual form, however, simple hypertrophy in its chronic stage, can be greatly benefited, and surgery usually prevented by the use of wave currents—alternating—with or without the addition of diathermic applications preceding the wave current. The procedure is carried out in the same manner as the treatment of a prolapsed sigmoid, save that the large surface electrode should be across the lower abdomen and prostatic electrode be in perfect contact with the rectal aspect of the gland.

A hypertrophied prostate, where surgery is too often prescribed, can usually be relieved of the pressure symptoms of difficult, painful or frequent micturition or a combination of the

above, by applications sufficiently often to produce results, gradually extending the time between treatments as conditions improve.

Fig. 64.

Prostatic Electrode.

Fig. 64 shows a prostatic electrode, the treating surface having a concavity to conform to the prostate for alternating current.

Diathermy with a proper fitting prostatic electrode just preceding the sine wave alternating surging current is probably the most valuable procedure. There is no cavity application of electricity where the maintenance of perfect contact is more essential than in this class of cases, and it is here that the rectal electrode support, Fig. 28, or some similar device should be used.

It is unnecessary to state that in using the current as above outlined, the metal abdominal electrode must be changed for a large, moist, surface electrode, while the prostatic electrode may remain in situ.

OBESITY

There are many areas of impaired function that can not be described in the list of diseases; conditions that have no pathology but have a tendency toward that end if allowed to continue, that may be classed under the head of symptoms belonging to general or faulty metabolism.

Obesity, for example, may be treated by diet alone, and if strictly followed, other conditions being equal, is likely to produce results. Passive exercises, whether manual or mechanical, combined with hydrotherapy, or without, will often relieve patients of adipose tissue, but as a rule, will produce only temporary effect, unless in conjunction with proper diet. Unless continued for a long period, this has a tendency to exhaust the patient and his exchequer. On the other hand, with the average obese subject, when the rigid diet is no longer observed, the patient will usually relapse into his former condition.

It is here that selective mechanical motion, the alternating surging current, according to the physiological action of the part under treatment, is the best procedure. This is because the prominent feature of the manipulation is that one will be able to tolerate a greater amount of rhythmical impulse, administered in a way that would not be possible with any other physical method. Other areas will be described in several of the "Techniques."

A combination of mechanical gymnastics, properly administered, and the careful adherence to diet will almost invariably produce quicker and more lasting effects. Where diet and proper exercise are combined in treatment, wrinkles and other objectionable features are less likely to occur.

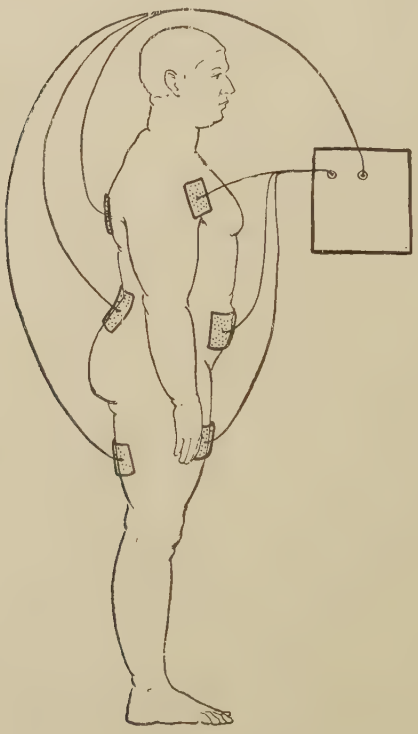
The probable explanation is that the equal period of rest and contraction gives the tissues a chance to recover and not become exhausted as would apply, for instance with an inter-

rupted galvanic or galvanic sinusoidal current. The latter are also objectionable because of the skin resistance, — burning sensation—which will be intolerable to the patient if the necessary forcible contractile effect is produced.

Small surface electrodes, using four or six at a time, could be utilized to advantage, not only in saving time, but that greater areas may be exposed to treatment at one time.

Fig. 65 represents how several pads may be used at one time in treatment of obesity, or otherwise, as one might desire.

Fig. 65.



CHAPTER IV

Relation of Epilepsy and Asthma to Intestinal Toxaemia.

EPILEPSY

Epilepsy is a name given to a condition which is characterized by convulsions. There are many diseases, especially of the heart and kidneys where epileptiform spasms simulate and approximate the so-called genuine epileptic convulsions. These are recognized as the direct effect of the existing toxaemia upon the spinal and cerebral nerve centers.

The disease epilepsy has its own special characteristics inasmuch as the manifestations are of a periodic nature, and range all the way from a slight disturbance, causing a mental aberration, to actual unconsciousness, accompanied by severe muscular contractions.

Whatever pathological changes may be detected in a post-mortem within the cerebrum and the medulla the patient has usually gone through life without the actual focal point in the etiology being discovered.

Several years ago Dr. Seaman S. Bainbridge, the well-known New York surgeon, called the attention of the writer to the hospital record of fourteen cases of epilepsy, in the various degrees which he had operated upon for intestinal stasis. Twelve of these, after one year, had not had a recurrence; the other two had improved. Since that time it is an almost univeral observation that epileptic subjects who have been successfully treated in a non-surgical manner, for their colonic toxaemia, have been relieved and many cases clinically cured.

It is understood, of course, that strict diet should accompany such a procedure. The pernicious and persistent use of bromides

in these cases so blunts reflex irritability that abdominal symptoms are often overshadowed because of the nature of exising manifestations.

It is hoped that the reader will not think that the author intends to convey the idea that intestinal toxaemia is the only cause of epilepsy, but it is certainly sufficiently common to warrant more credence than is usually given.

Epilepsy is a disease of such great importance that an X-ray examination by enema should always be made so that the foci of infection can be located and *definite* applications be applied pursuing the same technique as outlined for treating the caecum or sigmoid.

ASTHMA

Spasmodic asthma is due to a sudden contraction of the circular fibers, and consequent narrowing of the calibre of the bronchial tubes. It is influenced by climatic conditions, heart disease, so-called "indigestion," and is amenable only rarely to medical measures, only as the cause can be determined, as might be with accompanying bronchitis or a heart affection that might be relieved by appropriate remedies.

Asthma is one of the many conditions like hysteria and epilepsy due to reflex disturbance, where the spasm and nervous manifestations are the only things observed, and the resort to antispasmodics apparently the only thing to be done.

Enlarged prostate and intestinal toxaemia, with special reference to the sigmoid area, when relieved, has often shown a quick diminution of the spasmodic attack, and in proof of the assertion, the asthma returned just in proportion as the causes mentioned became active.

CHAPTER V

Cautions and Conclusions—Reactions following Physical Therapeutics—What Therapeutic Results may be Expected in the Treatment of Intestinal Toxaemia—Summary and Conclusion.

REACTIONS FOLLOWING PHYSICAL THERAPEUTICS

The average subject of intestinal toxaemia that physicians attempt to treat by methods outlined for constipation must be carefully watched at first, for fear of temporary disturbance.

The common practice is that of treating intestinal toxic areas first by diathermy, followed by the surging alternating current through the part. The toxemia thus liberated, if not in a reasonable time eliminated, produces a reaction in the form of headaches, general malaise, and even a temporary arthritis may ensue.

Let it be impressed upon those who have not observed these deleterious effects, or who are just commencing to use apparatus of the nature that would be employed for such conditions, that the first few treatments should be administered in such a manner that the patient will not be locally or constitutionally disturbed, to prevent not only discouragement of the patient, but bringing discredit upon a method, where a better understanding would avoid the necessity of explanation.

It is on the principle by which purulent areas are corrected by the surgeon by effective drainage, that intestinal toxins, especially about the caecum, should be carried away in the bowel contents, and not be set free and allowed to be re-absorbed.

To avoid the reaction mentioned, it is better to apply treatment for intestinal toxaemia twice a week, instead of three to five times a week—a common practice—thus giving the emunctories a proper time for elimination of the poisons set free.

WHAT THERAPEUTIC RESULTS MAY BE EXPECTED IN THE TREATMENT OF INTESTINAL TOXAEMIA

Not every surgical operation, medicinal administration, or physical and electrical application is productive of the results the patient expects and the doctor hopes for. All the way from amelioration of the symptoms to complete relief and restoration of function and the prolongation of life, is the object to be attained in the treatment of disordered functions and diseased conditions. This will be brought about just in proportion to the physician's ability to correctly diagnose, and his familiarity and knowledge of implements available for consummation of the object in view.

As previously stated, the resistance, age, and chronicity of the existing conditions must necessarily determine the length of time needed to produce a sufficient change in the tissues involved to restore impaired muscular tone. Subjects with firm abdominal walls, though the colonic angles be sharply defined, will respond more quickly than a similar intestinal condition with abdominal walls that are thin and less responsive to passive stimulation.

The average subject of constipation will usually respond more quickly if the rectal electrode is used as outlined elsewhere, than if the patient is treated by the common method through the body. Therefore, the prognosis in a case of intestinal stasis must depend upon the factors mentioned, also, the faithfulness of the patient.

A prolapsed stomach and colon, with the usual distortions at the flexures will not be anatomically restored, but if the motility of the muscalature of the intestines is improved and the function is restored physiologically, the patient can be considered clinically cured, if not anatomically replaced.

When one considers the disastrous effect of continuing cathartics, and the inability of other forms of medicine or surgery to

restore defective muscular action of the involuntary fibre, one should be contented, even should it be deemed advisable to return again and again for treatment, realizing that neglected areas of distorted physiological function have a strong tendency to become pathological regions that soon become beyond repair, where surgery is often attempted but disappointing in its result.

It is best that patients having a prolapsed and distorted colon, which of necessity requires a considerable time to bring about results, should be informed of that fact when treatments are first instituted, lest they receive the impression that they are to be "cured" in a short time, lose confidence, and question the capabilities of the physician.

It is not necessary to state that a radiograph of the colon taken before and after a reasonable number of treatments is the real scientific procedure to determine results regardless of the patient's statement.

IN CONCLUSION

The writer does not wish to leave the impression that just because so much has been written in this volume on the treatment of gastro-intestinal conditions that may be considered physiologically abnormal, the rhythmic wave impulse therapeutics as outlined under the term "sine wave current" can not be utilized elsewhere about the body. It has become a common practice among many physicians as an almost routine procedure to combine diathermy with the mechanical action of a modern apparatus, in an innumerable class of sub-acute and chronic maladies. With selective motion now obtainable by apparatus, physical therapy has become so generally adopted that massage and manual manipulation is thus being superceded.

By application of the principles, and a thorough knowledge of the mechanism, one can materially increase his therapeutic efficiency.

SUMMARY OF THE GALVANIC CURRENT

I. The galvanic current has two practical fields of usefulness; *a*, when waveless, and, *b*, when in waves.

II. The waveless galvanic current has a broad use in medical applications because of the production of stimulating chemical interchanges in a local part as a substitute for diathermy or in association with it; it is particularly useful in diffusing drugs into a part immediately below the appropriate pole; it diffuses sterilizing ions into infected mucous or abscess packets; arrests uterine hemorrhage; and when used in massive dose will destroy local malignancies.

III. The galvanic wave is chiefly valuable in the diagnosis of the results of injuries and disease of the motor mechanism.

IV. Galvanosurgery has a useful field in the destruction of accessible cysts and tubercular deposits; the removal of small skin growths; and the sterilization and healing of sinuses.

V. For the relief of pain and congestion it is the most dependable of all physical or electrical methods.

In a volume of this size, having for its object to teach principals rather than Physical Therapy prescription writing only, a comparatively few Therapeutic indications are mentioned.

Sufficient has been said so that even the novitiate may grasp the idea that the Galvanic Current has very definite properties, which when understood and appreciated, may be used with great benefit.

The Positive Pole should be applied on or about the painful or congested area for relief and on the other hand, the Negative would be the active Pole where congestion is desired for its nutritional or solvent action.

As for instance in a case of Facial Neuritis, Lumbago, Sciatica, or Cerebral congestion, the positive Electrode would be applied on or near the painful part and the Negative on the Solar Plexus, Abdomen, Ankle or some distant point, the strength of current to be determined by resistance in circuit.

If pathological conditions are reversed as in Facial Paralysis, Infantile Paralysis, Locomotor Ataxia and similar areas where the essential element is to restore nutrition, then the Nagative would be the Active Pole.

It is here that the unidirectional Galvanic Wave Surging Current can be used to great advantage.

The same principal applies throughout the body as regards not only local polar effect but interstitial as well.

SUMMARY OF SINE WAVE CURRENTS

I. Sine currents have by clinical evidence proven their efficiency in advanced therapeutics as a separate and distinct combined electrical and physical method, along with high frequency current and the various light effects.

II. The principle that any action, either heat or mechanical or combined, will produce a more pronounced liberation of toxins, giving nature a quicker response toward return of function than previous methods.

III. Clearly indicated and honest surgery must be respected, including gastric or duodenal ulcer, presence of gall bladder or nephritic calculi, salphinitis or other internal purulent areas, abdominal cysts, fixed visceral adhesions, etc., also acute inflammation generally.

IV. Following traumatism surgery or local disease, when nature in her attempt at rejuvenation fails entirely or only partially to bring about relief of impaired function of a part, sine wave currents as outlined in this book will, when intelligently used, prove a valuable adjunct to other remedial measures.

V. The interpretation in the minds of physicians just what a sine current is and definite indications for use has only recently been made clear in literature on the subject.

For anyone who has taken the trouble to study the fundamentals, the galvanic current, because of its definiteness of action, has not been difficult to understand; and for those, it is obvious why a wave current, from a galvanic source, should be uni-directional in character to maintain the important element, namely—Polar action.

A rapidly alternating sinusoidal current constructed so as to harmonize with cellular impulses, so rapid that any polarity action can not be detected, plus selective motion to correspond to physiological action of a part, removes the element of empiricism to a large degree.

VI. The importance of localizing in imperfect bowel elimination of the toxic regions and abdominal colonic flexures before instituting physical treatment, as one would outline a surgical operation, can hardly be overestimated.

The strong tendency towards malignancy in neglected intestinal stasis behooves the physician to always anticipate the possibility in the older subjects. The percentage of mortality from cancer of the sigmoid above is sufficiently large to substantiate it.

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